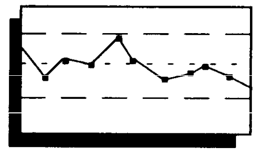
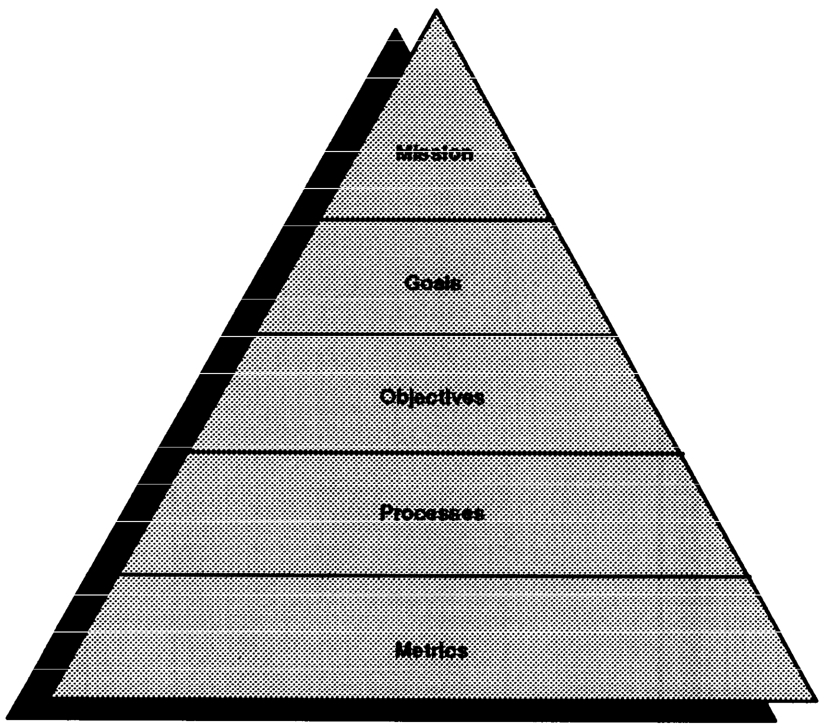
BY ORDER OF THE COMMANDER
AIR FORCE MATERIEL COMMAND

AFMC PAMPHLET 90-102
1 May 1995

Command Policy

THE METRICS HANDBOOK





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Pages: 118/Distribution: F;X
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Command Policy

The Metrics Handbook

This handbook provides the tools for managers to take that first step toward process improvement. You may find a striking similarity between this Air Force Materiel Command (AFMC) pamphlet and the Air Force Systems Command (AFSC) Metrics Handbook, dated August 1991. It was not our intent to remake an already successful and useful product. Therefore, we attempted to retain as much of the format and content as possible. Use it as a guide to help you identify what to measure, how to measure it, and recognize the importance of not measuring for the sake of measuring. It will provide you with the facts you need to take charge of your processes and help you take the right actions to make them better.

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Chapter 1: Introduction

Leaders must be dedicated to making things happen. Here, I'm talking about continuous improvement through leaders who never stop looking for better ways of doing things. By taking an inventory of our organizations, showing courage and taking responsibility, and being dedicated to making things happen, we will all be on our way to making today's Air Force even better.
(Gen Fogleman, Chief of Staff, USAF)

a. Handbook Purpose:

This handbook is about the world of "metrics"--a world which is often viewed from many different angles, with many different and varying opinions, and often with varying levels of belief or acceptability of the metrics concept. In this handbook, metrics may appear to be personified and raised to a level superseding all other things--that is only because the chief focus here is on metrics, metrics, metrics.... However, remember they are only tools; by themselves, in isolation, metrics do nothing, drive nothing. Only leaders and managers, acting upon a strategy or action plan, can drive the desired actions or behaviors. The metric records the strategy and measures results, but only management can act upon the results, correct errors, respond to changes.

This handbook is designed to help you develop and use metrics. Its purpose is to provide you with sufficient information to begin developing metrics for your own objectives, processes, and tasks, and to steer you toward appropriate actions based on the data you collect. View it as a road map to assist you in arriving at meaningful metrics and to assist in continuous process improvement. This handbook is the result of a team effort by people who have struggled to develop their own metrics.

b. Handbook Layout:

Chapter 1 answers your most basic questions about metrics and provides a foundation on strategic planning and command metrics. Chapter 2 provides the characteristics of good metrics and discusses what metrics are NOT meant to be. Chapter 3 provides a methodology for developing metrics and introduces the concept of the metric package. Chapter 4 explains performance and introduces some of the tools used in analyzing processes and developing metrics. Chapter 5 presents some guidelines and ideas for metrics presentation. Chapter 6 addresses implementation -- what to do with metrics once you have them. Chapter 7 presents a metrics development model along with worksheets to help you get started with metrics. The handbook closes with four attachments. Attachment 1 is a sample format for an operational definition. Attachment 2 is a brief orientation to the twelve basic tools introduced in Chapter 4. Attachment 3 is a glossary of terms helpful in understanding metrics. Attachment 4 is a resource of references that will provide you with more help.

c. Metrics - Measurements You Can Use:

Metrics are meaningful measures. For a measure to be meaningful, it must present data that encourages the right action. The data must be customer oriented, related to the product or service you provide, linked to the process generating that product or service, and supporting one or more organizational objectives. Metrics are also integral in measuring the success of our strategic plans. We put a plan in place to establish where we are and where we want to go, and then use metrics to measure our progress towards achieving those goals and objectives. Ultimately, metrics foster process understanding and motivate action to continually improve the way we do business. This is what sets metrics apart from measurement. Measurement does not necessarily result in process improvement. Effective metrics always will.

d. Why Metrics?

Metrics facilitate and sustain the "right" improvements. Metrics help us understand our processes and their capabilities so we can continually improve them. As Belasco points out "what gets measured gets empowered and produced."[1] Good metrics will help us "face reality, communicate it, and deal with it."[2]

e. Who Needs Metrics?

Metrics apply to any individual or any organization responsible for a task, activity, system, or process. You can use them at any level in an organization's short or long-range planning process or in any other ongoing or recurring task, activity, system, or process. One-time tasks and projects are still measurable, but the benefits of measuring may not be worth the effort.

f. Government Performance and Results Act:

The Government Performance and Results Act (GPRA) was signed into effect on 3 August 1993.[3] GPRA mandates outcome, results-oriented, performance agreements and performance measurement as a part of the daily management process. AFMC's concept of metrics is thoroughly consistent with the GPRA; so what you learn here will be directly applicable to meeting the requirements of the GPRA.

GPRA requires more formal, structured strategic planning and measurement systems to determine how well government agencies are achieving results in their plans. The focus is on outcomes--how the public is served by the program. Agencies will develop measures to determine outcomes and outcomes will be tested against appropriate measures. GPRA also requires close linkage to budget submissions. Specifically, the Act requires government agencies to:

- Establish a 6-year strategic plan to include the resources, systems, and processes that are critical to achieving the goals therein. The plan must have direct linkage to day-to-day operations.

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1 James A. Belasco, *Teaching the Elephant to Dance*, New York, NY: Crown, 1990, p 158.
2 Perry L. Johnson, *Keeping Score*, New York, NY: Harper & Row Publishers, 1989, p 111.
3 Material extracted from *A Government and Results Act (GPRA) Executive Primer*, 10 Jan 95

- Set performance goals to include key external factors that could affect achievement and,

- Report program performance annually.

The input-oriented processes used by most agencies today must transition into results-oriented systems which value outcomes and outputs. Again this is consistent with AFMC strategic planning and metrics.

g. Metrics and Command Strategic Planning:

As command leadership establishes the long and short range goals and objectives for the command, a tool they use to link feedback from their plans to the results is metrics. Metrics are an integral link from the detailed plans at the lowest levels of implementation to the highest levels of planning. The command strategic plan starts when the senior leadership develop the command mission statement, as shown in Figure 1-1. The strategic vision for command direction in the coming years is then articulated through a series of statements and pronouncements which become more detailed as they flow throughout the chain-of-command. At each level of management, metrics are the diagnostics, created by process owners, which measure progress in meeting command goals and objectives.

Senior leaders articulate their plans by conducting a strategic analysis of major internal and external issues which impact the command both positively and negatively. They determine responses to ensure the command mission can be accomplished. Goals and their subordinate, implementing objectives provide further details for implementing the senior leadership's direction. These goals and objectives provide broad guidance which is definitized in the command's strategic plans, action plans, and business plans. Each level of management develops an implementing strategy on how they will carry our their objectives and develop a metric which is used to gauge progress in implementing their plans and strategies. If progress is made in obtaining the desired end result for the objectives, this positive action will also serve to further the command's goals and mission. In striving to obtain the objectives, each level of management will examine their critical processes, determine means to improve them, and create metrics tied to the objectives to track results. The organization's strategic plan records the command's goals and objectives, their own supporting objectives, critical processes, and associated metrics. The strategic plan is the glue (not the metrics) which cements the command's long range visions together from the command level to the worker level. It all starts with leadership, but it is the responsibility of every member of the command to implement the command's mission.

The strategic plan and guidance cascade throughout the command providing the linkage and cohesion necessary for a forward-leaning, proactive Air Force. The strategic planning is repeated at each level of the command: command, mission element boards, Headquarters directorates and functional offices, centers, wings, and process owners. As each level builds their strategic plan, they must work with the preceding level to determine how they should be supported and flow-down guidance to the succeeding levels. The integration of strategic planning guidance and cascading of strategic plans ensures a

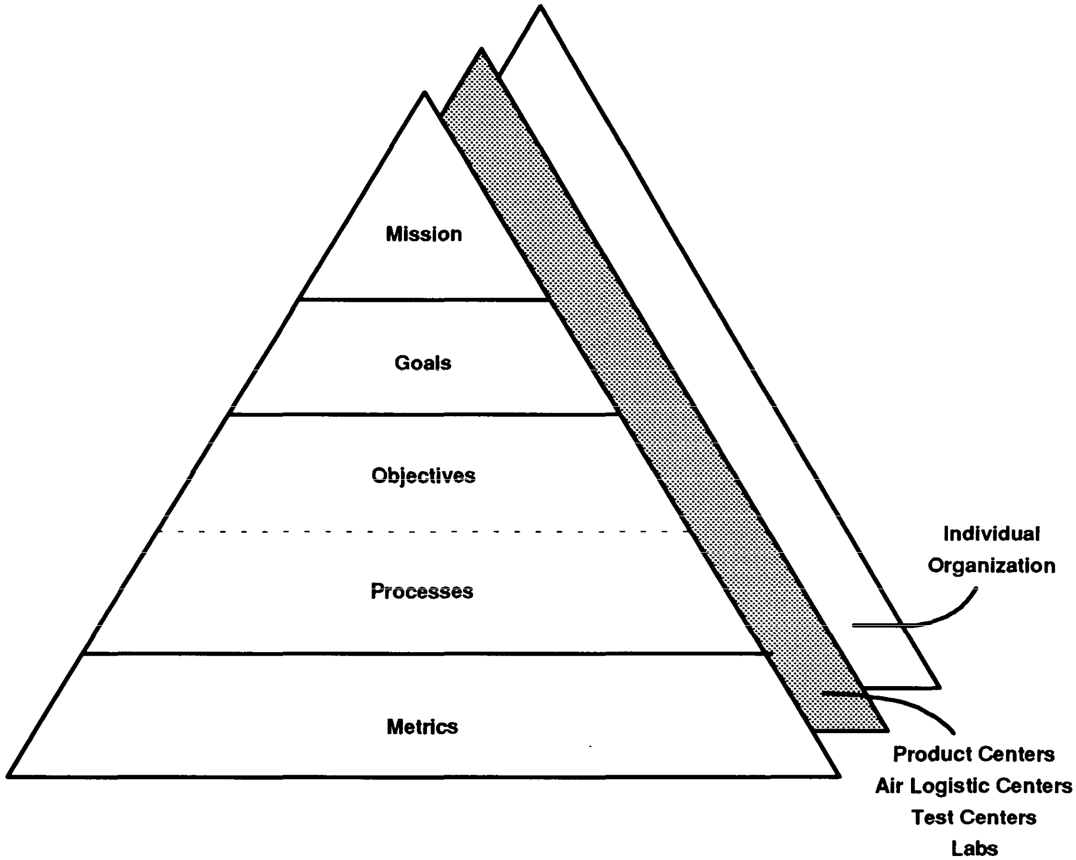

Figure 1-1. Command Planning Framework.

seamless and consistent flow of direction and information. The command's goals and objectives are formulated by the command's senior leadership (Strategic Vision) and are cascaded through each level of the organization ("Top-Down" Vision) providing a consistent command focus. Each level translates the preceding level's objectives and the command guidance into a plan, objectives, and strategy which can be implemented at their level. These supporting objectives provide the necessary focus at that level while contributing to the success of the preceding level. Figure 1.2 illustrates the cascading technique from the command level to the mission element level.

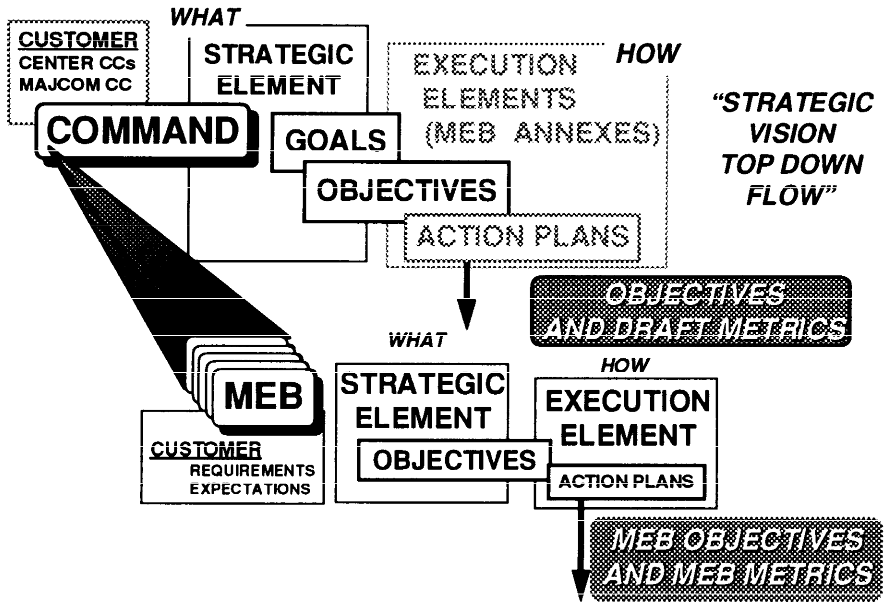

Figure 1-2. Cascading Strategic Plans.

While we speak of two separate levels, in fact, they are integrated. The mission element boards are part of the command board which is responsible for developing the command strategic vision and strategic plan. The mission element boards contribute to the development of the command goals and objectives. The command plan strategic element provides the "what," or the command's mission statement, strategic vision, goals, objectives, metrics, and situational assessment. The annexes, or execution elements, to the command strategic plan provide the "how" for the plan. The mission element strategic plans are incorporated as the annexes and provide the actual blueprint for executing and accomplishing the direction contained in the strategic element. The strategic element from the preceding level (i.e., the "how") always forms the foundation for the execution element (i.e., the "what") for the succeeding level (see Figure 1-3). Strategic plan development is an iterative process and requires a significant amount of communication between levels. Vision/direction is established at the top and, as it is cascaded each level, determines how they will contribute; thus plans become more detailed and precise (and not necessarily larger).

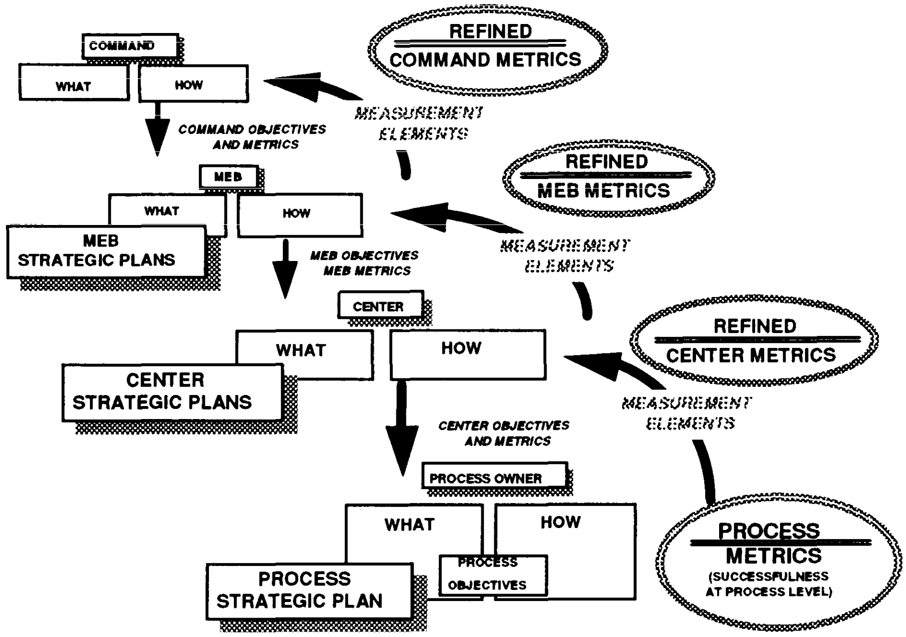

Figure 1-3. The Iterative Process of Strategic Planning.

This technique is also true for the metrics; their command level scope is established at the top and each succeeding level adds focus appropriate for that level. This does not necessarily mean we want aggregated "drill down" measures because aggregation often hides the real issues. Instead of aggregating the metrics, the linkage must be through the plans. At each level we want metrics which independently measure that level's success as well as its contribution to the next higher level (see Figure 1-4 for an example). The first iteration is not complete until refinements are made based on what and how the lower levels can actually contribute.

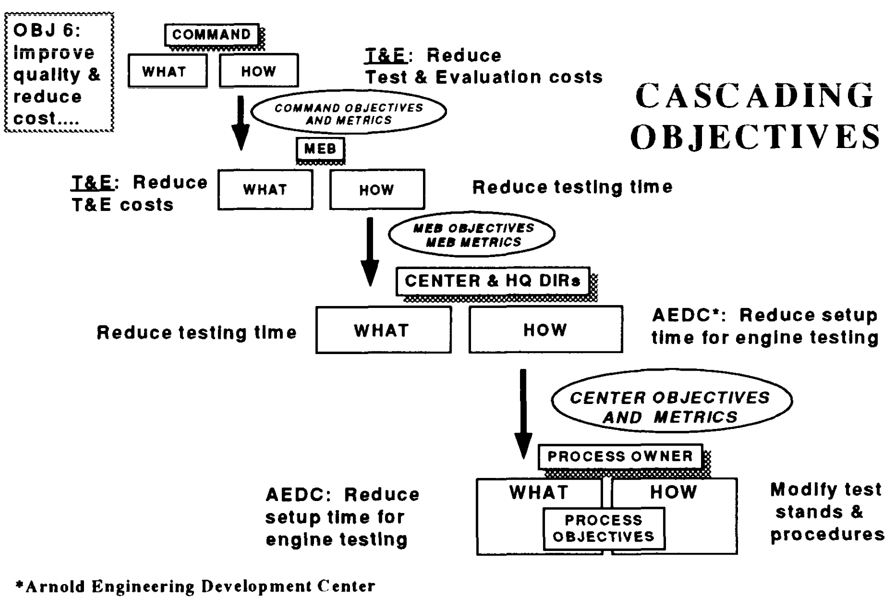

Figure 1-4. Example of Cascading Objectives.

Chapter 2: Fundamentals

a. What Metrics Are:

Metrics are measures of how well we are performing. This implies several things. Most importantly, our metrics must be tied to customer expectations and requirements. Second, a metric must communicate the "health" of our process. Third, the metric must distinguish health from sickness. To know what health means, we must know where we are now and where we want to go. Fourth, a time dimension and an improvement plan are necessary for true metrics.

For purposes of this handbook, a metric is a measurement made over time, which communicates vital information about the quality of a process, activity, or resource.

Measurement is a means to an end: continuous improvement of the way we do business.

b. Attributes of a Good Metric:

The following are the basic characteristics of a good metric:[1]

1. It is meaningful in terms of customer requirements.
2. It tells how well organizational goals and objectives are being met through processes and tasks.
3. It is simple, understandable, logical and repeatable.
4. It shows a trend, i.e., measures over time.
5. It is unambiguously defined.
6. Its data is economical to collect.
7. It is timely.

BUT MOST IMPORTANTLY:

8. It drives the "appropriate action."

[1] Derived from the 26 Sep 90 AFSC Commander's Staff Meeting handout

c. What Metrics Are Not:

Metrics Are NOT merely:

1. Charts. Charts may graphically display the results of a metric. However, the chart itself is not the metric.
2. Schedules. Some forms of schedule can lead to good metrics, but usually a schedule does not provide information that by itself will lead to process improvement.
3. Goals, Objectives, Strategies, Plans, Missions, or Guiding Principles. Most of these can be measured, but as stated above, the metric is not by itself the end. It is a means to an end -- achieving objectives and goals through continuous process improvement.
4. Counts of Activity. Counts of activity can result in metrics, but just because you have statistics does not mean that you have a measure that will drive appropriate action.
5. Snapshots or one-time status measures as displayed in pie charts, stoplight charts, etc. These convey little trend information. Comparison of status over time can be a metric, but it tends to be very top level and does not provide much understanding of the process.

d. The Correct Metric Perspective:

In order for today's managers to become truly successful, they must expand their management perspective by putting their customers first. In the past managers often concentrated only on performance measures or management indicators which focused on measuring **OUTPUTS,** as in Figure 2-1, (i.e., how many made, number serviced, sorties flown, records processed, number of green indicators, etc.)--normally it was too late to be proactive because information was feedback of what has already happened. Although this type of information may be necessary, we must make a paradigm shift to sustain the quality improvements needed to ensure our future viability.

Traditional Measurements Are One-Dimensional
Focusing Only on OUTPUT

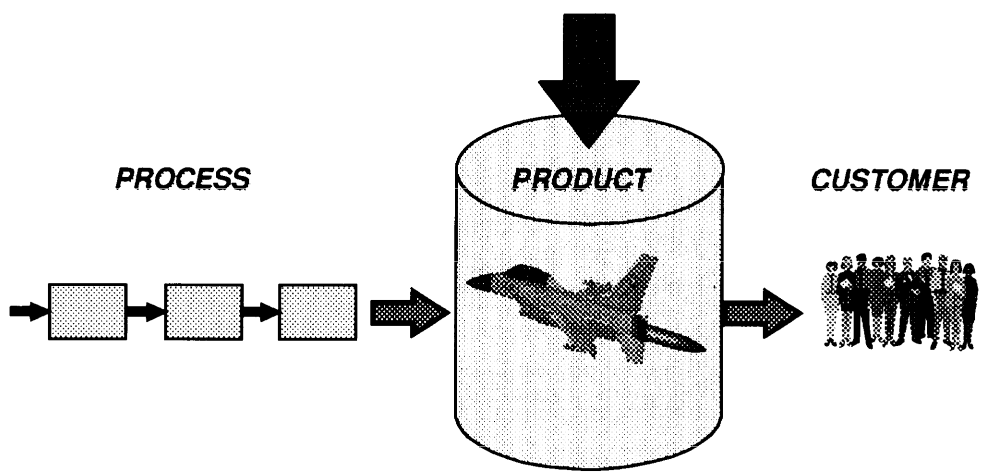

Figure 2-1. Output Only Perspective.

We no longer can afford to consider just output or production numbers. To be competitive and drive the **right** improvement behaviors, we must plan, manage, and measure progress predicated on the Mission-Customer-Product-Process relationship shown in Figure 2-2. [Note: this relationship is depicted sequentially left to right from a production/service perspective]. We want to focus on the entire Customer-Product-Process relationship as one system and how it serves to meet mission requirements. To do so we must begin with the customer--they are the ones who define quality and product characteristics which we, the process owners, build into the process. An **OUTCOME** perspective, Figure 2-2, will ensure planning, management, and measures are focused on delivering products or services which meet all the agreed upon customer requirements in the most effective and efficient manner possible, while striving for continuous improvements which are in the best interest of both the customer and the "overall" organization.

Based on the Customer—Product—Process Relationship,
Modern Measurements (METRICS) Focus on the
Entire Relationship (OUTCOME)

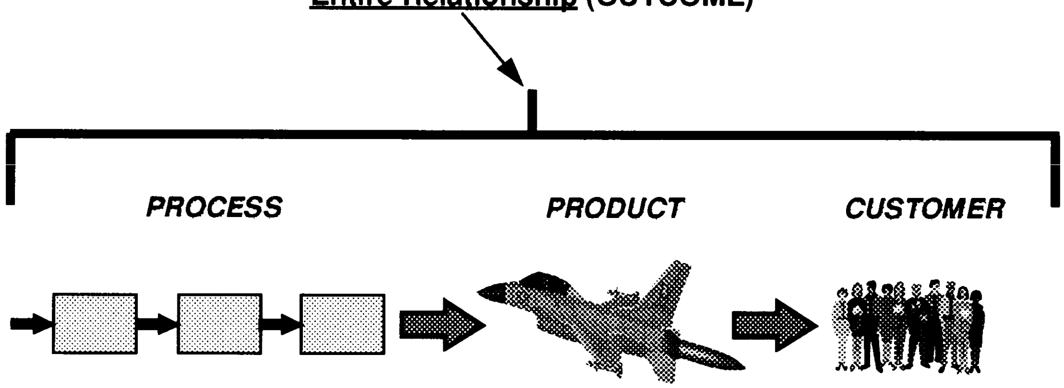

Figure 2-2. Outcome-Oriented Perspective.

Begin by determining who your customers are, considering both internal and external, and their level of importance to your organization. When dealing with internal customers, exercise precautions to avoid sub-optimization. Remember *customers* are the individuals you deliver your products or services to and are seldom your supervisors or superiors; make your customers happy and your bosses will be happy. Discover your customer requirements, without becoming a burden; remember surveys are only one of several means and do not have the flexibility or value of one-on-one communications. You and your customer must not only agree on what you will do for them, but also on what you won't do--in this day and age of limited resources you can't do everything. This is an iterative process; things change; today's desires become tomorrow's requirements; keep customer communication an on-going activity.

The next step is to have the customer define the product characteristics and negotiate and establish your product commitments. *Product* is the item(s) or service you provide to your customer. Your strategic plan is a vital part of this effort. Your organization's goals, objectives, and commitments provide the necessary direction and focus to balance your customer and mission requirements. Again, be sure to avoid sub-optimization or limit yourself to the status quo -- aggressively pursue product improvements. *Process* is how you build, deliver, and service the product. Faster, better, cheaper is the general theme, but each must not be improved at the expense of the others or without the best interest of the entire organization in mind. This is where metrics (if properly designed and employed) can be used to drive the right behaviors and sustain continuous improvements. Develop, document, and maintain an improvement strategy not only to show where you are trying to go, but also as a historical lessons-learned document.

Figure 2-3 illustrates how metrics can focus on the entire relationship. Two types of metrics logically flow from the Customer-Product-Process relationship:

Effectiveness—measures provide information on how well the product meets your customers' expectations. Remember the customer defines the quality characteristics of the product, and if the customer is not satisfied with the product (to include all necessary support: equipment, training, documentation, service, etc.) then you are not addressing the whole Customer-Product-Process relationship or taking an outcome perspective.

Efficiency—measures provide information on how well the process produces the product. Efficiency measures must address more than just numbers produced; equal consideration must be given to cycle time, defects per unit of measure, output per unit input, and the other quality measures. Tailor your measures based upon your mission and customer requirements.

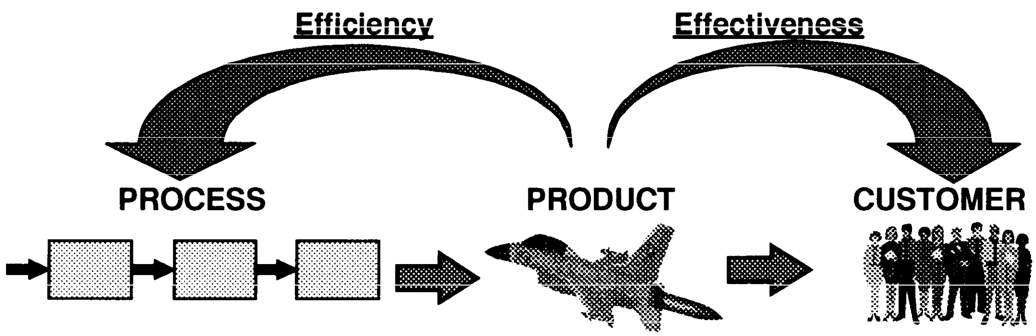

Figure 2-3. A True Metric Perspective.

In many cases it is possible to develop or combine measures of efficiency and effectiveness into one multi-dimensional system metric. In doing so, it may take several underlying types of measurements or support metrics to manage your system. However, your customer-focused metric(s) must depict the overall health of your entire system (the Customer-Product-Process relationship) and outcome success.

e. Metrics and Process Variation:

All processes exhibit some degree of central tendency and variation. Assuming central tendency is focused on the customer requirements, continuous improvement of any process means pursuing uniformity of output, that is, reduction of variation. If you do not know the variation of a process and you change the process, you risk having no effect or making the process worse. You will be "tampering" with the process rather than systematically making improvements. A balance is needed between the fine line of tampering and inaction. Experience with a process will often provide managers with a "gut-feel" of when action or intervention is needed. If a manager decides to act (with a feeling that he/she may be potentially tampering) a systematic metric is still highly recommended to document and assist in the process improvement effort. Here the metric may provide insights that go beyond the "gut-feel" and experience of the manager as well as measure the success of the process improvement actions. The discussion of normal and abnormal variation and the use of histograms and control charts described in the Attachment 2 provide useful information for interpreting metrics.

Chapter 3: Development Process

a. General:

The previous chapters of this Handbook focus on providing you with the theoretical framework of metrics. This chapter deals with the nuts and bolts of developing metrics. First, it provides some general metric guidelines along with overall philosophy concerning the use and purpose of metrics. Then it describes the concept of a physical "Metric Package" with a step-by-step process for developing metrics.

b. The "Metric Package":

As mentioned earlier, metrics are measurements used to drive continuous improvement. Not all measurements are metrics--some measurements have the potential to become metrics, but not all. The most important part of your metric is the journey you embark upon as you develop and maintain your metric -- provided it is given the appropriate level of attention and sincerity. Your attitude and philosophy will evolve as you recognize the benefits metrics bring to your organization and its customers. A well thought out and maintained metric package is vital to your success; it will be your vehicle to recognize opportunities for improvement and proactively avoid obstacles, as well as to document and communicate your journey. The metric package is compiled to clearly define the metric and is what differentiates it from a mere measurement. A metric package consists of the following three basic elements: the operational definition, the actual measurement and recording of data, and the metric presentation. Together, these elements comprise the metric package, as Figure 3-1 illustrates. The operational definition is the precise explanation of the process being measured. The measurement and data collection is the translation of process data into understandable and useful information for the process owner and stakeholders.

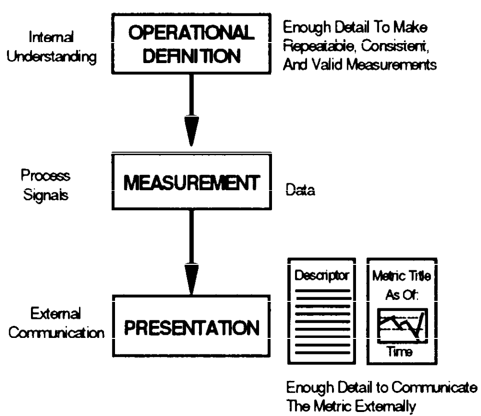

Figure 3-1. The Metric Package.

The first element of the metric package is the operational definition. According to some "there is nothing more important for the transaction of business than the use of operational definitions."[2] The operational definition is the who, what, why, when, where, and how of the metric. It must be detailed enough to allow valid, repeatable, and consistent measurement over time. It

[2] W. Edwards Deming, *Out of the Crisis*, Cambridge, MA: MIT CAES, 1986, p. 276.

also helps internal communication, fosters process understanding, and serves as a vital step towards focused improvement efforts (the key will be your improvement strategy). The amount of detail required will vary from metric to metric, but, at a minimum, it should consist of the elements shown in Attachment 1, Operational Definition: A Sample Format.

The second element is the actual measurement of the process. This is the step of collecting and recording the data. This step is often seen as the heart of the metric concept, but, in reality, only severs as the translation of data from the process being measured to meaningful information that will be the basis of your process improvement activities (see Chapter 6). The journey of the "thinking" is the actual heart of metrics; the what, where, and how metrics will be used to sustain continuous improvement.

The third element of the metric package, the metric presentation, has two parts. The first part is the metric descriptor and the second part is the graphic presentation of the data. You would normally plan the descriptor and presentation when developing the operational definition, before collecting data. The amount of detail required in the descriptor will vary with the purpose of the presentation. At a minimum, the descriptor will include a clear definition of the metric, the source of the data, the population that the metric will include, the owner of the process the metric measures, and identification of the portion of the strategic plan to which this process links. It should contain enough detail to clearly communicate the information contained in the graphic presentation. The metric's graphic presentation, or its "chart(s)", is often mistakenly referred to as the metric. In conjunction with the improvement strategy from the operational definition the descriptor and the chart should provide enough information to clearly communicate the metric. These are further discussed in Chapter 5.

c. Getting Started — Generic Metric Guidelines and Philosophy:

At the beginning of the metric process, the prospective metric developer should first answer (and document) fundamental questions that focus on the *mission-customer-product-process* relationship and how the metric will support the overall mission or purpose of AFMC. This provides the foundation of information and focus upon which the rest of the process relies; for a valuable metric to be created, this step must be carefully accomplished and documented. When completed, the metric developer should have a clearly defined metric requirement which is focused in the right direction and at the appropriate level.

1). Before attempting to write a metric there are several questions we must answer so we can focus our attention in the right area. Develop and document the <u>metric concept</u> by answering the following questions:

Who/what initiated the requirement for this metric?

Why is a metric needed?

What product/service will benefit from this metric?

Who is the ultimate customer of that product/service?

Do we understand the customer's expectations?

What must we excel at to meet the customer's requirements?

Are the customer requirements/expectations consistent with our strategic plan?

How do customer requirements tie or link to our product/service?

Which process supports those products/services?

Will the metric measure one of our organization's most important processes?

Is the overall process understood well enough to avoid sub-optimization?

In the area proposed for measurement, can we continue to improve and create value? (Innovate, Remove Constraints, Educate)

Who will use the metric to make decisions and what type of decisions?

2). Some questions to think about now, but answer thoroughly later:

How will our metric link to and support our strategic plan?

Does our supplier understand our requirements?

Where are the best opportunities in our process to improve product/services based on customer requirements?

The ultimate question after achieving improvements: How do we look to our stakeholders, i.e., how do customers, CEOs, stockholders, Directorates, Generals, HQ, etc. view our organization, our products and services, and our processes?

3). Next we want to review some fundamental perspectives on metrics and a few basic characteristics a metric must have to be effective:

A metric should be designed to motivate *positively* versus a scorecard.
If personnel are concerned about reprisals, the metric data must be suspect. Switch from a scorekeeper to a coach.

Metrics should not be created just for the sake of having metrics.
Exercise caution when generating new metrics or measurements even for very worthwhile suggestions. Creating metrics just for the sake of metrics is taboo and leads to proliferation and dilutes the importance of all metrics.

Only measure a handful of the most critical items.
Remember companies rarely fail from having too few measures, but have failed because of too many. Attempting to handle too many metrics at one time is impractical and leads to management of metrics instead management by metrics (facts).

The metric should address "cross-functional integration."
Measuring by functional specialty fragments and isolates an organization, thus potentially promoting and rewarding behavior that may hamper an organization's ability to improve. Without integration, functional specialties may document outstanding performance in their individual areas and yet in reality may be hampering or even preventing achievement of the organization's overall objectives and improvement potential. In addition, measuring "cross-functionally" requires fewer measurements.

Take the time to view metrics from a macro (system) perspective.
Balance what is good for the organization versus just your section. The measures should be designed to pull personnel towards the overall objectives of the organization.

Metrics should create a feedforward management atmosphere.
This is in contrast to an organization where decisions are strictly based on feedback type data. We must create metrics to help us see where our organization is headed, not just where it has been. Managing an organization with metrics should be like driving a car. We don't drive our cars down the road by staring in the rearview mirror. We look forward -- concentrating on where we are going. We choose the best path by looking for those opportunities and obstacles ahead of us, then we maneuver accordingly, always trying to improve our position. Metrics should find opportunities and keep us focused -- use metrics to steer your organization into the future, not just to track its past.

Focus on Customer Satisfaction--let it drive what you're trying to measure:
cycle time
quality (attributes or defects per unit)
employee skills (improving knowledge, skills and abilities)
productivity (meeting commitments)

Bottomline: Are we developing, supporting, and delivering what we said when we said?

4). **Helpful Hints.** Sometimes people have difficulty getting started on creating effective metrics. Two generic measurements, cycle time and defects per unit, can be applied to almost any process. When they are used together, they provide an excellent starting point for developing a meaningful metric.[1]

Cycle time is more than just measuring how long it takes to generate a product or service. Instead it is evaluating the process length from the customer's perspective. The clock starts with the initiation of the request and ends when the customer gets the product and necessary support required to keep it functioning as originally intended.

Defects per unit (per process opportunity) — a defect or attribute is any deviation from the customer's requirement. Identify the customer as the next person in the process (internal or external to the organization). This is measured with respect to the overall process performance, i.e., how many defects occur per process opportunity rather than defects per product or per end item or service provided. Many corporations are now using six sigma as their benchmark, which means they are working towards having no more than 3.4 defects per million opportunities. Recognize that measuring "every" opportunity is the ideal state; begin by setting your goals realistically e.g. defects per hundred or thousand and work up from there. Include measures of defects per output (the customer's perspective) and defects per process task opportunity (your internal perspective).

To achieve true effectiveness, both measures must be used without sacrificing one for the other. Metrics pertain to everyone and to all portions of any process. Consider all facets of the process: administration, research and development, engineering, contracting, support data, packaging, shipping, etc., not just

[1] Larry W. Emmelhainz, "TQM Principles and Measures: Key to Successful Implementation," *Air Force Journal of Logistics*, Summer 1991, p. 35

maintenance or manufacturing. Keeping in mind that the customer defines quality, if an organization can fulfill the customer's requirements by delivering a defect-free product, and do so in a timely manner, then cost will also be the lowest possible.

d. The Steps of the Metrics Process:

This section provides the steps for formulating the metric package and measuring associated process improvement. Keep in mind that these steps may require tailoring before applying them to your particular situation. Figure 3-2 illustrates these steps with an example.

STEP I. IDENTIFY PURPOSE OF YOUR METRIC

It is important to first align your purpose with your organization's mission, goals, and objectives. These should focus on meeting customer needs and serve as a foundation for accomplishing and sustaining continuous, measurable improvement. With your strategic plan in hand, identify and document your products/services and customers. Address the questions: What do you provide? Who are your customers?

STEP II. BEGIN DEVELOPING AND COORDINATING YOUR OPERATIONAL DEFINITION

Define the who, what, when, why, and how of this metric in sufficient detail to permit consistent, repeatable, and valid measurement to take place. The operational definition starts with a basic understanding of your process. This is followed by a precise understanding of your customers' expectations resulting from discussions/negotiations with them. You then "operationalize" the agreed upon expectations by defining the characteristics of the product/service and then linking them to process characteristics which are internally measurable and which, if improved, would better satisfy your customers' expectations. The crux of the operational definition is your improvement strategy. This documents your philosophical approach to using the metric to achieve process improvements. This is actually an iterative process involving Steps II-VII. The operational definition is the first element of your metric package (see Attachment 1 for a sample format).

STEP III. IDENTIFY AND EXAMINE EXISTING MEASUREMENTS

Once you have established the linkage between customer-product-process and identified the potential metric's criteria, it is essential to determine if existing metrics or other measurements satisfy your requirements. Don't "reinvent the wheel"--when appropriate use existing process measurements.

STEP IV. GENERATE NEW METRICS IF EXISTING METRICS ARE INADEQUATE

Most measurements used in the past were not process improvement oriented. They were indicators related to final outputs (products or services) for external customers. As discussed in Chapter 2, metrics focus on how well our processes produce products or services and how well our products/services meet customer expectations from an "outcome" perspective. We are interested in those upstream process measures which drive the final outcome and are key to making process improvements. The assumption is: if you monitor and improve process performance based on the customer-product-process relationship (see Chapter 2), the quality of the products and services will improve. If you need new metrics, refer to Chapter 7 for a detailed development approach.

STEP V. EVALUATE YOUR METRIC AGAINST THE "EIGHT ATTRIBUTES OF A GOOD METRIC"

Refer to the attributes of a good metric listed in Chapter 2. If your metric sufficiently satisfies these criteria, go on to Step VI. If not, return to Step II and correct the deficiencies.

STEP VI. SELECT APPROPRIATE MEASUREMENT TOOLS

Select the proper tool for analyzing and displaying your data. The "Twelve Useful Tools" identified in Figure 4-1 are those most commonly used. Other statistical and non-statistical tools may be more appropriate for your application. Use whatever you feel is best. The tools are discussed further in Chapter 4 and Attachment 2.

STEP VII. BASELINE YOUR PROCESS

Start acquiring metric data. This serves as a baseline for determining the capability of your process. Ask if the data is accumulated over time and adequately measures the important characteristics of your process. If the answer is uncertain, examine other possibilities. During this step you should finalize your metric's operational definition.

STEP VIII. COLLECT AND ANALYZE METRIC DATA OVER TIME

Continue collecting metric data over time. Examine trends. Special and/or common cause effects on the data should be investigated. Compare the data to customer expectations, goals, etc. This is the second element of your metric package. See Chapter 6 for details.

STEP IX. FINALIZE THE METRIC PRESENTATION

When data is available from previous steps, you are ready to design the metric presentation. The descriptor will provide enough information to communicate the appropriate details of the metric. Determine the appropriate level of detail through discussion with the process owner and stakeholders. This information should be an abbreviation of the key elements of the operational definition. The graphic presentation clearly and concisely communicates how you are performing. This is the third element of your metric package (see Chapter 5).

STEP X. INITIATE AND DOCUMENT PROCESS IMPROVEMENT ACTIVITIES

Initiate and document process improvement activities in conjunction with the process owner and key stakeholders. Chapter 6 provides more guidance on this area. Remember, continuous improvement requires continuous effort. THIS STEP IS THE MOST CRITICAL FOR YOUR IMPROVEMENT EFFORTS TO BECOME A REALITY. Remember that metrics are just a means to an end! That end is continuous process improvement.

STEP XI. CONTINUOUSLY MONITOR AND TRACK PROCESS IMPROVEMENT. RETURN TO PREVIOUS STEPS AS APPROPRIATE

Make an assessment of the metric results. When it becomes apparent that the metric is either no longer needed or does not contribute to process improvement, return to the appropriate step in the metric development process.

Chapter 7 illustrates one method for developing metrics, along with its step-by-step mechanics and details.

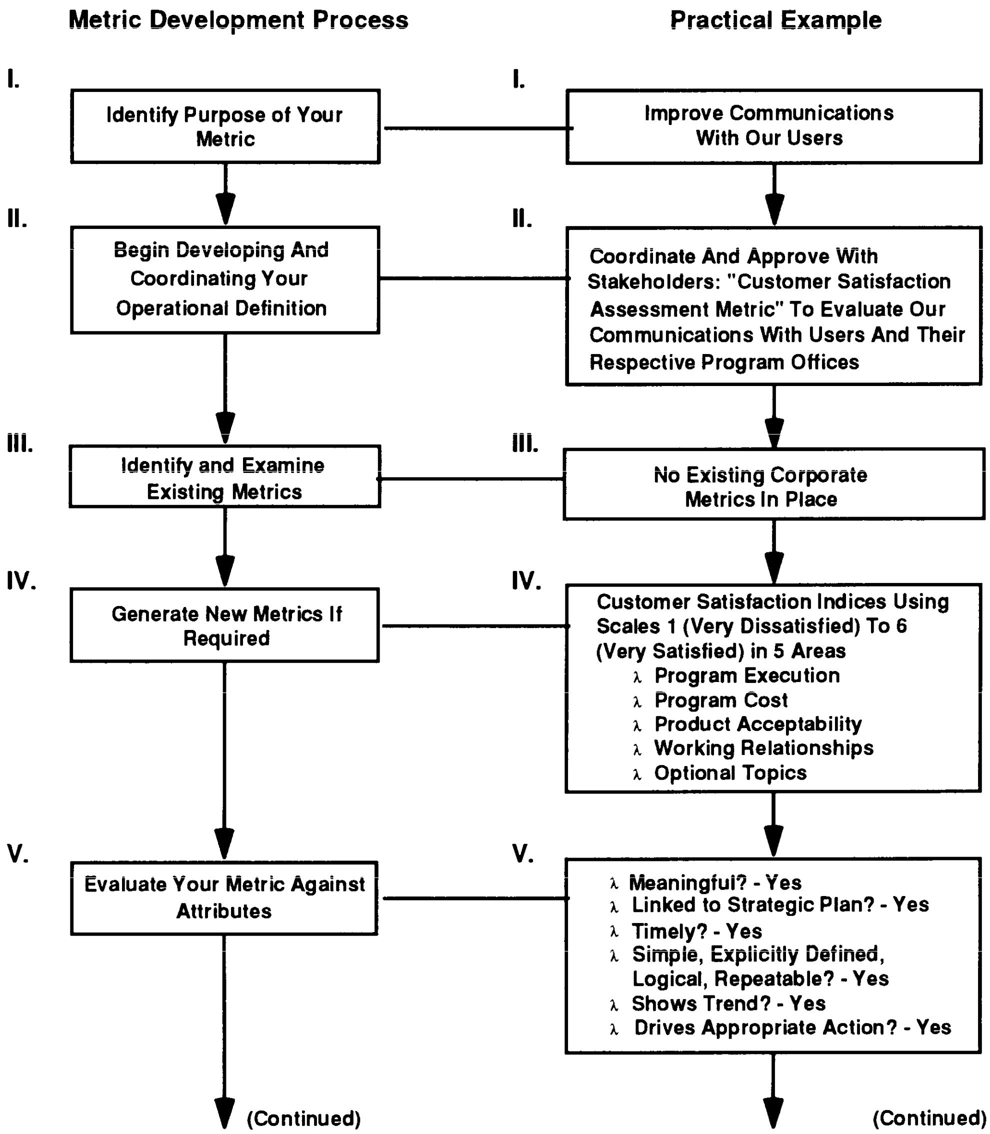

Figure 3-2. Metric Development Process.

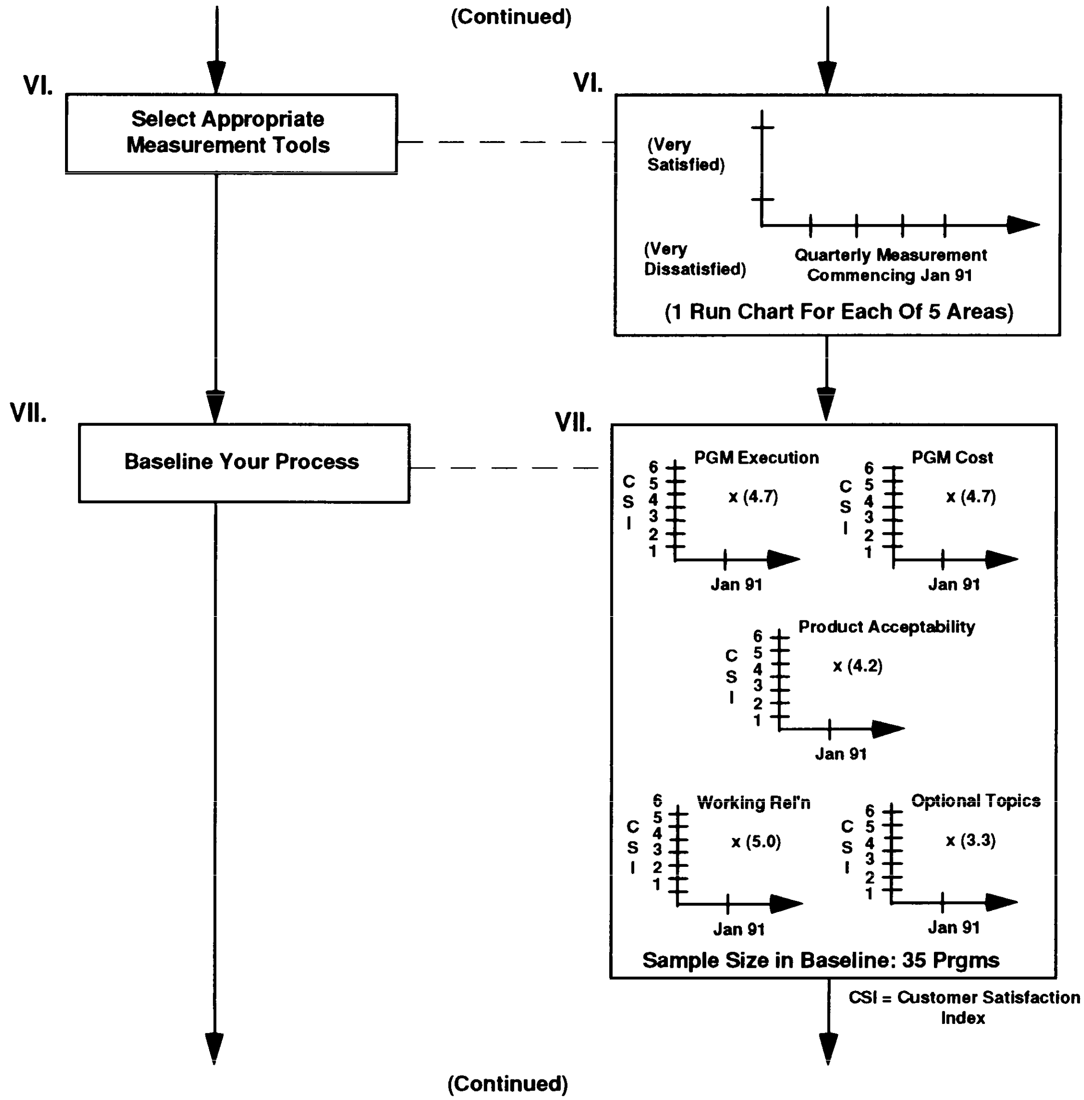

Figure 3-2. Metric Development Process (continued).

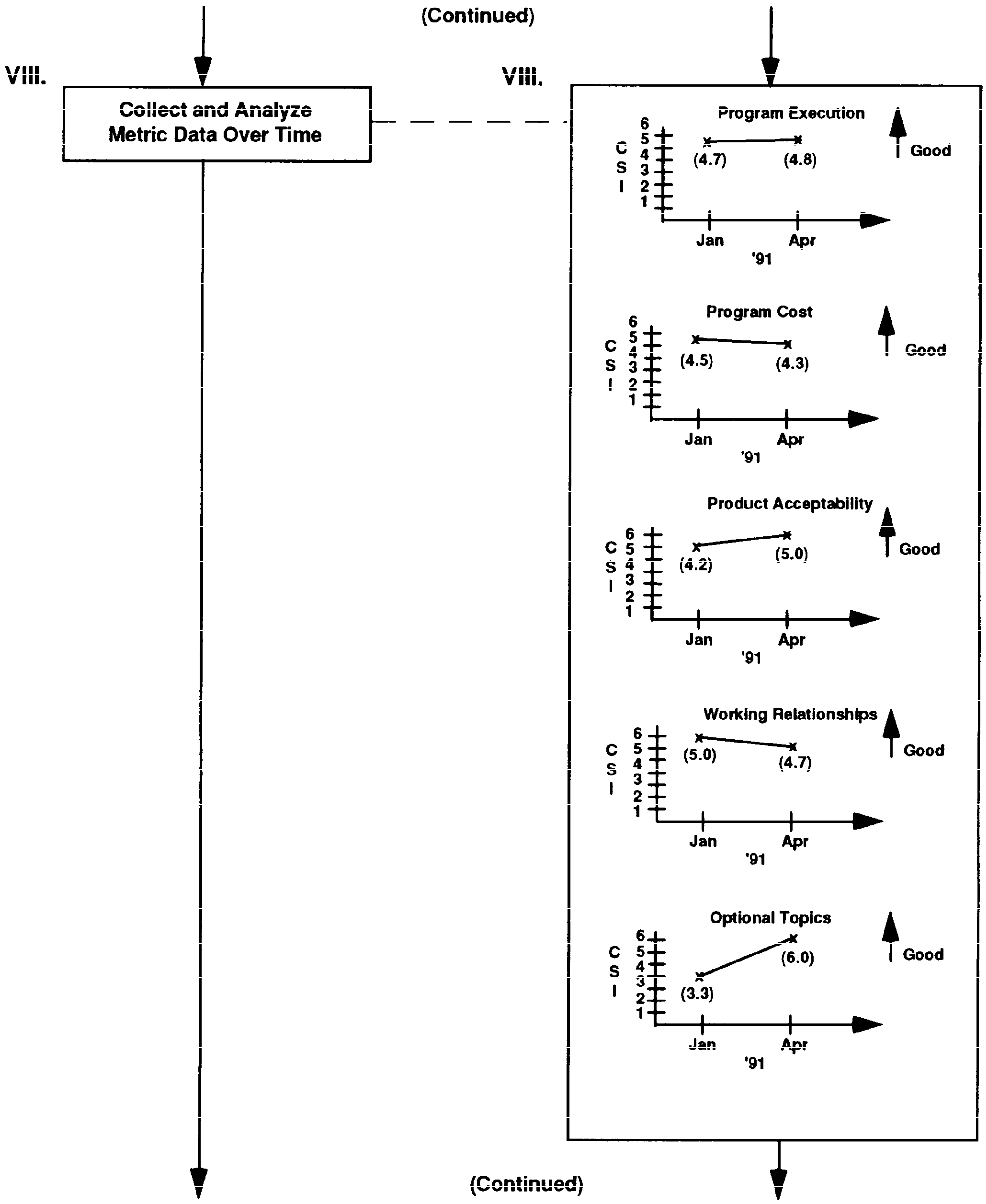

Figure 3-2. Metric Development Process (continued).

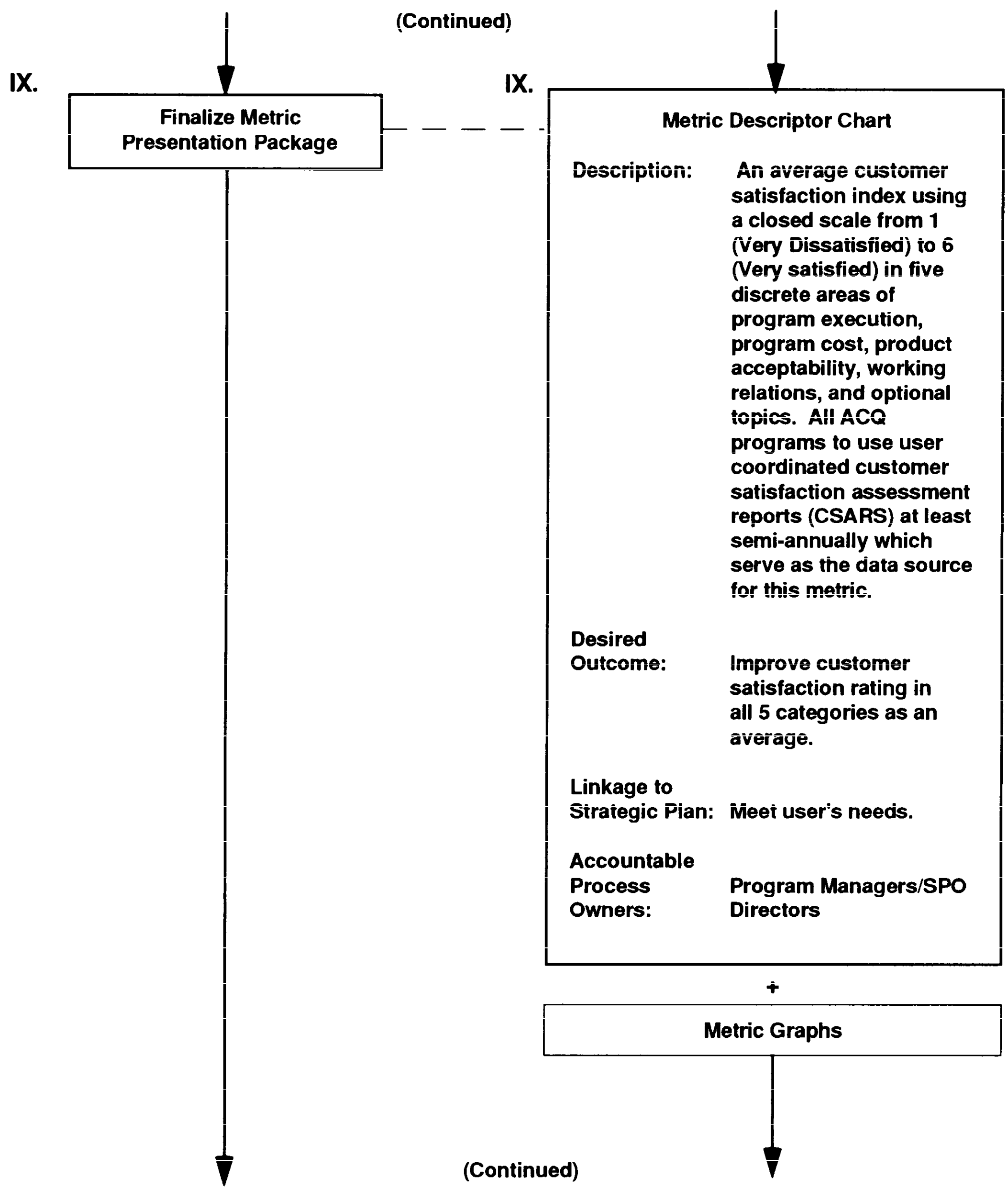

Figure 3-2. Metric Development Process (continued).

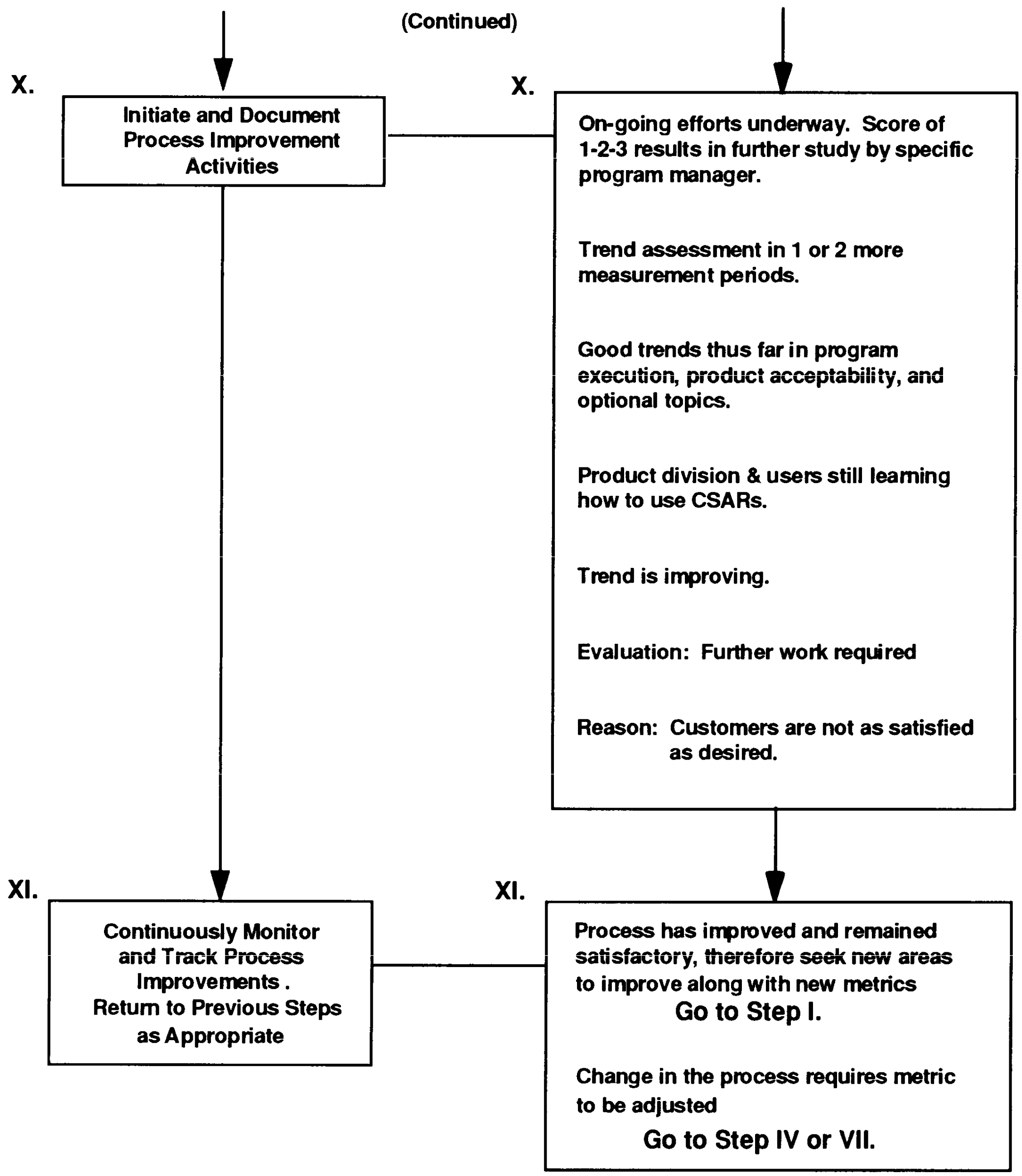

Figure 3-2. Metric Development Process (continued).

Chapter 4: Introduction to Quality Tools

a. Process Performance:

This chapter introduces process performance and several common tools that will be useful in developing metrics.

Process performance considers how a process works and how well. Since the customer defines quality, you need to analyze the system in terms of mission-customer-product-process relationships to determine its capability to meet customer needs and expectations. The tools in Attachment 2 will help you interpret the data you collect. These tools are a bit like x-rays used by doctors--they help you understand how your process is currently performing.

Recognizing and understanding the variability of your process is important for systematically improving processes. Why study variation? All processes have some amount of inherent variation. It is important for managers to understand and react properly to changes in performance data (i.e., metric trends) in order to make sound decisions and avoid tampering. At the same time, managers and process owners should also be seeking, implementing, and sustaining process improvements. Some of the consequences often associated with misunderstanding normal variation and/or tampering with process performance are:

- Unpredictable performance.
- Additional reviews and inspections to weed out undesirable results.
- Avoidable rework and/or scrap.
- Schedule delays.
- Lower productivity.
- Lower reliability.
- Higher costs.
- Customer dissatisfaction (which, by definition, means poor quality).

Discussion and evaluation of variation typically revolves around a tool called control charts. These tools are helpful in discovering how much variability in a process is due to random variation and how much is due to unique events. The control chart evolved out of the manufacturing realm where large run quantities of the same item were being produced on an automated assembly line. In that environment it was important that the machinery tolerances did not vary excessively in order to produce uniform products. It was important to identify machines that needed adjusting before defective products were produced and scrapped. The primary focus was to maintain the stability of the manufacturing process. Today's competitive, resource-limited environment is much different: we must seek continuous improvements of our processes--not maintenance of status quo. It is imperative, then, that **if you choose to use control charts for continuous improvement, they must be applied in the appropriate context.**

There are two types of variation: normal variation and abnormal variation.

Normal variation is the inherent fluctuation of process performance resulting from process components such as manpower, machines, work methods, materials and the work environment. Over time, process indicator data may go up or down, but you can predict the range of variation with a reasonable degree of certainty. Normal variation occurs because of "common causes." These may be the level of training of individual employees in a process, the reliability and condition of equipment, procedures normally used, or simply minor random events. For example, consider driving your car to work everyday. Common causes resulting in different daily driving times include the day of the week, various amounts of traffic, time of day, timing at traffic lights, other drivers, etc.

Abnormal variation results from "special causes," that is, something unusual or outside the process has happened. For example, errors have increased because a manager assigned a new and untrained employee to a critical process. Sometimes people close to the process can eliminate special causes without changing the process itself. Most special causes are unpredictable. Sometimes they are beyond our control (e.g., severe acts of nature) while others can be anticipated and minimized with contingency planning. Going back to the example of driving to work, a snow storm in Florida and its impact on driving time would be a special cause.

Common causes account for the vast majority of the variation in a process, yet frequently managers tend to react to daily fires--many of which are special causes. Therefore managers need process performance metrics which help focus their attention on <u>both</u> special and common causes of variation. Fires (special causes) still get put out, but continuous improvement emphasizes reducing the effects of common causes of process variation.

Process variation is often disguised. Therefore, you need to look at your data and your metrics from several perspectives. The questions you want answered about your process so you can improve are:

- What is the total variation in the process? Histograms and basic descriptive statistics will help here.
- What is the short-term stability of the process? Control charts (or range values) will reveal this.
- What is the long-term predictability of the process? Run charts and control charts will provide the answer.
- Is the variation normal or abnormal? Histograms and control charts can help distinguish between these two types of variation.
- What is the best opportunity for improving the process? Where should I focus my resources <u>first</u> for improvements? Cause and effect diagrams, Theory of Constraints, and Pareto charts can help isolate and focus your efforts. Reengineering and benchmarking may also be helpful.

b. Tools:

Process control tools, such as control charts, are not the only tools which are useful for process improvement. You must decide which approaches are appropriate for your applications. The tools most commonly mentioned in the quality literature are control charts, run charts, flow charts, cause and effect (or fishbone) diagrams, histograms, Pareto diagrams, scatter diagrams, check sheets, Theory of Constraints, reengineering, and benchmarking.[1]

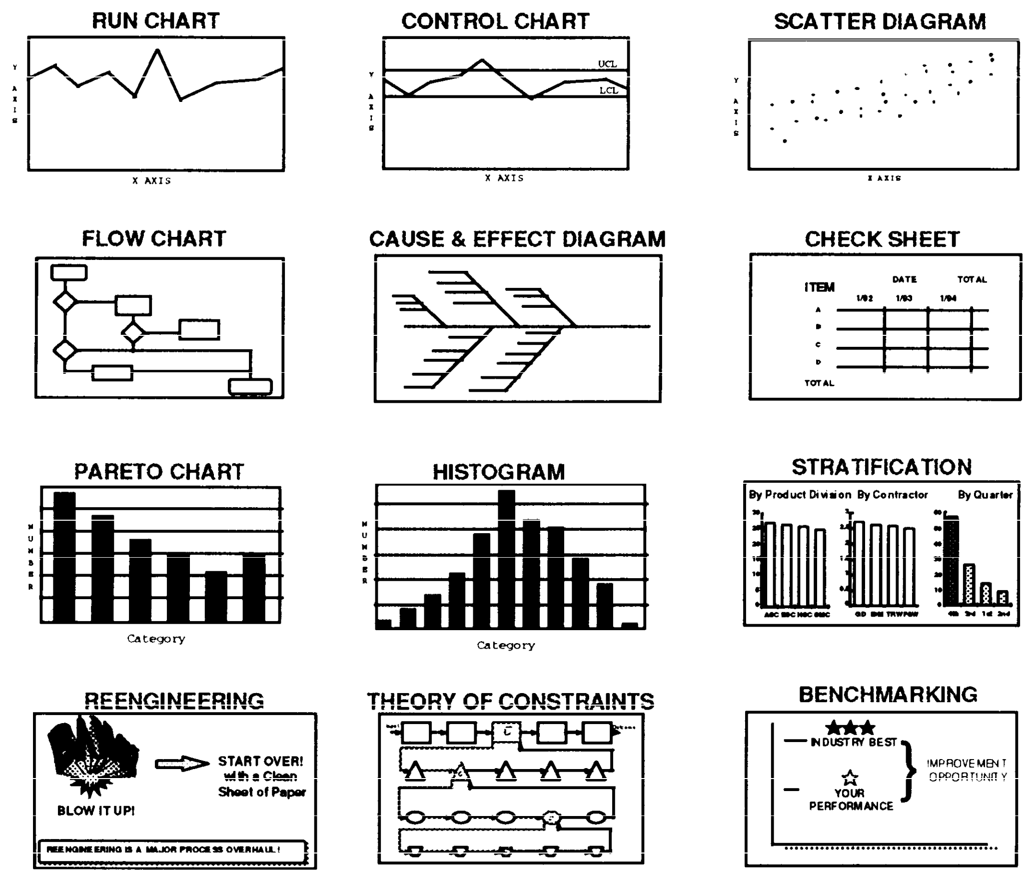

Figure 4-1. Twelve Useful Tools.

Above (Figure 4-1) is an illustration of these twelve tools. Of these twelve , run charts, control charts, and scatter diagrams show process performance information over time. The other tools help you identify problem areas and focus in on an improvement strategy. There are many more tools, available to the interested user. Table 4-1 should help you determine which of these tools may best apply to your situation. Those who understand the process are in the best position to determine which statistical techniques to apply. Before using a tool, you should take the time to understand it. Many courses and books are available as indicated in Attachment 4. A good place to get assistance is your organization's quality office.

[1] *Memory Jogger*, Walton, Booz Allen, Scherkenback, Klemeie, et al.

TABLE 4-1.
OVERVIEW OF QUALITY TOOLS.

Tool	Potential Use	Attributes	Metric Application	Comments
Run Chart	To display trends and visualize process performance	- Measures process - Shows time dimension - Shows trends - Simple	- Exploratory - Observation - Data over time	- This alone is not a metric - Preliminary tool; do not dwell on variations
Control Chart	To track and analyze process variability.	- Measures process - Shows time dimension - Indicates events in or out of control - Shows the variability within a process - Use to differentiate common and special causes	- Proper execution of the mechanics does not always correlate to proper use - Use when process has high repeatability & the goal is stability - Excellent tool for manufacturing applications - Exercise caution when attempting to apply to management processes	- Do not confuse CLs with spec limits or customer requirements -CLs are arithmetically determined from actual data, while spec limits are based on requirements or needs - "In control" implies product is consistent, yet does not reflect acceptability.
Scatter Diagram	To visualize & discover correlations between variables	- Illustrates relationships between two variables - Depicts dependence or independence of the variables	- Normally a preliminary tool to focus attention - Not appropriate as a metric without recognizing changes in the variables over time. - Becomes a powerful contribution to your metric when you use something like regression to anticipate the future to become more proactive	- Do not confuse this with a run chart - The data plot only shows the relationship between the variables; it does <u>not</u> imply cause and effect - A means to begin focusing attention when combined with a cause & effect analysis
Flow Chart	To analyze/breakdown a process into steps,	- Clear visual linkage and display of process tasks/steps	- Assists in understanding process interrelationships - Can be used to recognize areas needing measurements	- Be careful to keep a "macro" perspective - Add detail as appropriate/relevant to problem or improvement effort
Cause & Effect Chart (Fishbone)	To identify problems and potential solutions	- Shows relationship between possible causes and effects	- Can assist in identification of where attention should be given first	- Focus on identifying the root causes of the problems, not just the symptoms

TABLE 4-1. (CONTINUED).

Tool	Potential Use	Attributes	Metric Application	Comments
Check Sheet	To collect and classify data	- Easy to understand - Good for counting and stratifying	- Data collection tool which supports the metric	
Histogram	To display data frequency distribution	- Distribution depicts: range, central tendency, variability, potential outliers, etc.	- Assists in understanding how single variables affect the system - It could help identify potential measurement areas, i.e., is this variable a significant factor	- Histograms usually show a number of occurrences for a specified time period - Be creative --display multiple time periods on one chart to illustrate trend
Pareto Chart	To separate "vital few" from "trivial many."	- Form of bar graph - Clearly displays relative importance of problem or conditions.	- Assists in identification of where attention should be given first - When trends are added to the chart (in the right situation) could be used as part of the metric presentation	- Exercise caution in drawing conclusions from straight "counts." - Often a good lead-in for problem solving
Stratification	To indicate one or two significant problem areas; use when your original Pareto chart does not clearly identify them	- A way of "cutting" or "slicing" data along different natural or logical lines -Illustrates patterns of how the data points cluster or do not cluster	- Sorts data into groups or categories based on different factors - Valuable problem isolation tool; use to zero in on root causes (diseases) - Helps reduce mis-diagnoses	- Factors may include: type of job, equipment, day of the week, team, time, product, region, season of the year
Reengineering	To recreate/redesign your organization based on the ideal way processes should work (completely unconstrained by current paradigms)	Most applicable when: - Continual improvements are NOT getting your organization there fast enough - The gap between where your organization is and where your organization wants to be is too big - Your organization is dysfunctional	Key ideas to keep in mind when applying this tool: - Design so process steps are in natural work order - Combine several jobs into one (integrate) - Compress both vertically and horizontally - Reduce checks and controls - Explore customer-supplier partnerships - Provide single point of contact for customers	Although we may not be able to re-engineer an organization in its entirety, we can and have applied the concepts at the process level

TABLE 4-1. (CONTINUED).

Tool	Potential Use	Attributes	Metric Application	Comments
Theory of Constraints	**Throughput Analysis** To understand a process from a system prospective **Thinking Process** To determine the effect-cause-effect relationships of a process/problem	**Throughput Analysis** - Helps find the process' weakest link (constraint) based on a total system-wide perspective. Then focus your process improvement efforts at the constraint - Helps to balance resources relative to the constraint **Thinking Process** - concentrates on the elimination of undesirable effects (UDE) by finding and correcting root causes	- Methods to focus on identifying the root causes of the problems, not just the symptoms - Valuable problem isolation tool; use to zero in on root causes (diseases) - Helps reduce mis-diagnoses - Reduces the chance of sub-optimization, because it encourages you to look beyond just your functional area and focus on the entire system	When a specific constraint has been alleviated, take another system-wide look and find the "new" constraint; this is an on-going iterative approach to continuous improvement **TOC** is extremely powerful because it readily exposes the underlying assumptions and the silent paradigms which are resident in all organizational networks
Benchmarking	To measure your products, services, and practices against the toughest competitors or industry leaders to ascertain your relative strengths and weaknesses	Helps you recognize the gap between your organization and where it could be Pit your processes against others' to learn without reinventing the wheel Gives idea of where to focus your continuous improvement activities	To use this tool properly, you must: Know your operation - Assess your strengths and weaknesses - Identify the process to be benchmarked Study other organizations - Know the industry leaders or competitors - Identify who does what best Incorporate the best practice - Understand why it is the best - Tailor that practice to fit your needs Become the best - Continue to compare and evaluate - Strive to become the benchmark for others	It is important to know industry leaders--find out who does what particularly well so you can learn from them. But don't merely copy what they do; rather it is more important to understand what they do and why. Then look for ways to apply those ideas. No one will have exactly the method you can use--you will most likely need to pull many pieces together from several leading organizations. Organizations don't have to be similar -- only the particular part of the process you are trying to improve

Chapter 5: Presentation

This chapter provides guidance for graphically depicting your metric to communicate the progress and success of your improvement strategy.

There are two basic elements which make up the Metric Presentation Package. The first element is a metric descriptor which defines your metric and provides other essential information about the metric. The "descriptor" is defined in Figure 5-1 and an example shown in Figure 5-2. It is important to develop the operational definition as specifically as possible prior to formulating your metric descriptor. Spending as much time as is warranted on both will pay rich dividends downstream in terms of reduced confusion and accuracy.

Metric Title

Description:
Briefly and unambiguously define your metric along with the population you will measure and the source of your data. These and other items of information on your metric should be contained in your metric operational definition.

Purpose:
What specifically you are trying to improve

Desired Outcome
The change in behavior that will occur if the performance measured by the metric improves. Expressed in terms of a positive or negative trend (not a numerical goal).

Linkage to Strategic Plan :
Identify one or more of your organization's objectives or goals that this metric supports. This linkage to your organization's plan is essential; this includes how the metric is meaningful in terms of customer requirements.

Process Owner:
The principal individual who is directly accountable for providing a specific product/service to the customer(s).

Improvement Strategy:
A brief summary of your improvement strategy to include philosophy, actions, and results.

Figure 5-1. Metric Descriptor.

The second element of a Metric Presentation Package is a "graphic illustration" of how the metric tracks over time. The illustration should be simple to interpret. Some potential tools and displays are introduced in Chapter 4 and are explained in more detail in Attachment 2.

In addition to the guidance presented in Attachment 2, a few other helpful hints are appropriate. Ensure your graph has a title, and both axes have labels as well. Don't limit yourself to depicting time only on the horizontal or x-axis; you might find it beneficial to display trade-off characteristics on the x- and y- axes and time as a third dimension by the plotted data points as depicted in Figure 5-3 (the graphic illustration for Figure 5-2's descriptor). Use a common marker for each data string such as an x or o. A common practice is to construct your chart so that improvement is shown as movement "up and to the right" (see Figure 5-3). It may be appropriate to use an upward or downward arrow to indicate your preference (i.e., what direction on the graph indicates improvement) for raising or lowering the metric overall in time. If a control chart is deemed the appropriate tool, plot the center line and upper and lower control limits. *Remember upper and lower control limits are statistically calculated based on your process' past performance.* These control limits are **not** customer expectations or needs; therefore, also include a line to illustrate those customer expectations.

Metric Title: F-16 Landing Gear Repairs

Description: The production of individual landing gears is measured with respect to the total amount of time it takes to run it through the depot repair cycle and the number of defects under the control of the landing gear shop. Time accounting begins at the point where the part is received at the depot and ends at the point where it is received at a customer's supply point. Defects include customer reported deficiencies on landing gears received.

Purpose: Reduce the repair cycle time while also reducing the number of defects.

Desired Outcome: Produce a higher quality product in a shorter time. Make people aware of the need to improve quality while getting repaired landing gears to the customers (F-16 single product manager and operational wings) faster.

Linkage to Strategic Plan: Command Objective 6: "Improve the quality and reduce the cost of our products and services...." MEB Supporting Objective XX. Center Objective YY. Organizational Objective ZZ. Ultimately the objective is to have high quality landing gears readily available when required by the customer.

Process Owner: OO-ALC Landing Gear Division

Improvement Strategy: Establish an Integrated Product Team (IPT) to investigate potential time-savings opportunities. Examine training requirements for reducing scrap and rework. Maintain a balance between speed and defects based on customer requirements. Evaluate progress monthly.

Figure 5-2. Sample Metric Descriptor.

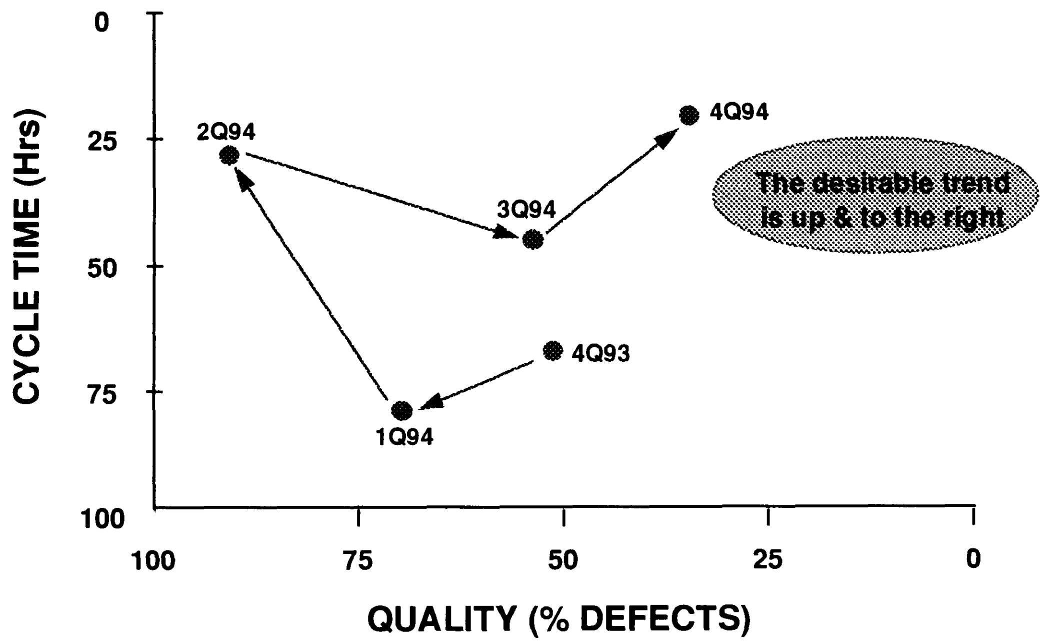

Figure 5-3. Sample Metric Graphic.

Finally, a comment on "Stop Light" charts is appropriate. Management may wish to assign a color rating or color-code for each measurement period. Figure 5-4 provides an example of such a color assessment scheme. Work with your customer to establish your assessment criteria early-on, and stick with them over time. Avoid changing your criteria in mid-stream, particularly to prevent your colors from going to yellow or red. Remember metrics are for performance improvement--not to show what a great job you are doing.

Green	Achieving commitments or objectives
Yellow	In danger of not achieving...
Red	Not achieving...

Figure 5-4. Sample Stoplight Criteria.

The assignment of a specific color may depend on the trend of your metric over time. Figure 5-5 illustrates how to integrate a Stop Light chart into a metric graph.

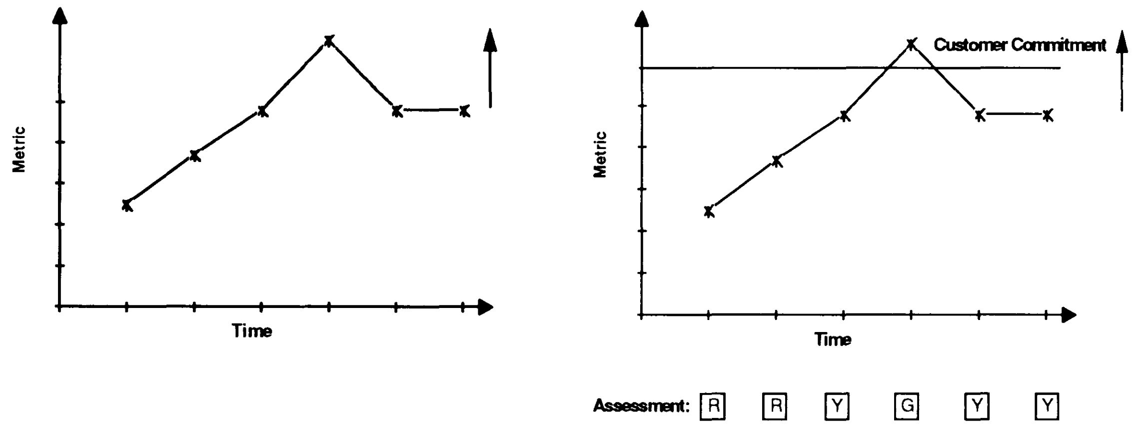

Figure 5-5. Sample Stoplight Assessment.

Your targets or thresholds, if numerically defined, should not be arbitrarily established. In defining your targets and thresholds, carefully consider your customer's needs or specifications AND attain a thorough understanding of what your process is capable of accomplishing. Then, with your customer, negotiate mutually acceptable commitments in the form of targets and thresholds. If a color code is also necessary, establish your color-coding criteria with customer agreement, and maintain consistency in this criteria over time. WARNING: Aggregating "colors" only masks problems. Remember we don't "average" colors--this tool is used to quickly isolate problem areas needing attention--so don't be afraid to report the "lowest" color.

Chapter 6: Implementing Metrics for Process Improvement

a. Introduction:

This chapter deals with the task of using data and metrics to systematically target and implement process improvements, and to then monitor and evaluate the effect of these improvements. Once you have established your improvement strategy, begun to gather data, and have a presentation format, you are ready to take the next, and most important, step in the metrics process. This is the step of actually using the metric to drive improvement within your organization.

The process began with the "Top-Down Vision" captured in the strategic plan. Implementation continued when you and your customers reached agreement on their requirements. Implicit in that agreement was a commitment to make improvements in your products/processes to meet those requirements. Your job is to use fact-based management, i.e., metrics, to achieve the appropriate behavior leading to the necessary improvements.

Figure 6-1 illustrates an iterative approach for sustaining continuous process improvement. Use it as a guide for continually taking action based on what your metrics tell you. Remember a distinguishing factor between taking a measurement and having a metric is the ability to implement change based on the accumulated data. Only after exercising the "follow-up" step of implementation have you successfully developed true metrics and taken full advantage of them.

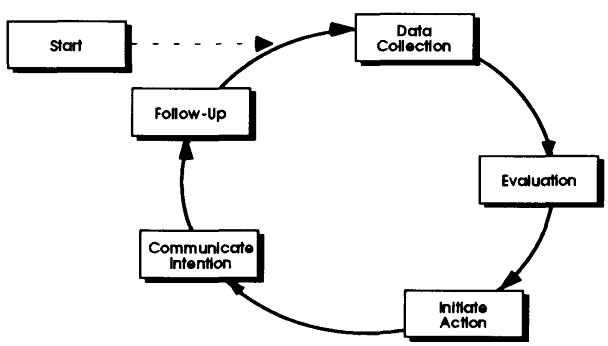

Figure 6-1. Metric Implementation Cycle.

b. Data Collection:

One of the attributes of a good metric is that the data must be economical to collect. In addition, the data must be meaningful to process owners and decision makers who use the metric to drive improvements. The amount of data required depends on the particular metric and process. One should exercise caution to avoid tampering when minimal data is available. However this is not a sufficient reason to do nothing--one should use whatever data is available to help focus on opportunities. The data can't make the decision for you--the decision comes through your interpretation.

c. Evaluation:

As mentioned earlier, every metric package should include a desired outcome. A fundamental step in implementation is evaluation of where you stand--with respect to meeting your customer's needs, with respect to corporate goals, and with respect to the appropriate benchmark. As a minimum, this evaluation should result in clear understanding of your success in achieving your improvement strategy.

An important tool in making your evaluation will be your customers' perspectives and feedback. Customer satisfaction is paramount, and cannot be over-emphasized. It is vital to consider the customers' inputs in any assessment of performance and process changes.

Your evaluation may also be based on an assessment of your position relative to that of others, often your competition (real or perceived). Such an assessment can be extremely beneficial, but only if a positive attitude toward benchmarking exists. In the past, military organizations tended to perceive comparisons with a "report-card mentality." However, a competitive evaluation may foster improvement by demonstrating the ability to improve a particular process and by suggesting possible approaches to make improvements. Extreme caution must be taken if one develops competitive-type measures <u>within</u> the organization. If these foster competition by pitting one internal group against another, they can easily promote wrong behaviors (e.g., sub-optimization, withholding of innovations, etc.) that are detrimental to the organization as a whole.

The model shown in Figure 6-2 illustrates an iterative approach to managing, evaluating, and improving process performance based on your metric. This model is a metric-specific delineation of Shewart's Plan-Do-Check-Act (PDCA) improvement cycle and an evolution beyond the simpler and more generic problem-solving steps of "where we were--what we did--where we are--where we're going." While the three models are very consistent with each other, you may have to do more than one iteration to complete the "management by metrics" cycle. Use the one with which you are most comfortable.

1. Review the metric trend. At this point you are trying to get a "big picture" perspective so don't get hung up on the mechanics of formal trend analysis. Begin by reviewing your operational definition to remember exactly what your metric is measuring and what you are trying to accomplish. Then take a look at the actual metric data. What does the trend data indicate? Is it going up or down? What is the magnitude of the change? Was the change unusual? If you had previously made changes to your process, what effect did these changes have on your metric data? Reactions to metric "trends" can drive a lot of actions (some of which may not be appropriate). In order for managers to act "properly" to changes in data(i.e., to metric trends), it is important that they understand the basics of variation.

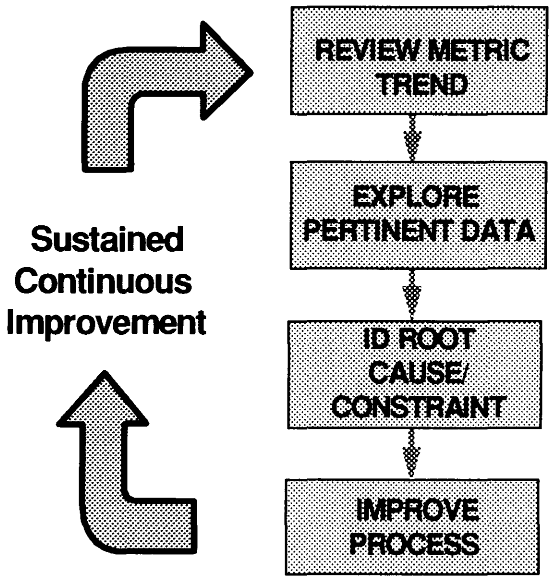

Figure 6-2. Iterative 'Management by Metrics' Process.

In some situations it may be appropriate to use Control Charts. In those cases, Upper Control Limits (UCLs) and Lower Control Limits (LCLs) provide the "arithmetic boundaries" to evaluate whether or not a process is in control. However, the true measure of success must be evaluated with respect to customer requirements, not the control limits. In most cases it is not necessary to use such a formal approach--a simpler evaluation may adequately lead to "appropriate action." The point is that your evaluation need not be complicated. In the next step you'll probe the data deeper for greater insight.

2. Explore pertinent data. Do a first-look analysis to identify process symptoms. It is important to do analysis beyond just the metric data points; consider external impacts on the metric as well, e.g., funding cuts, personnel reductions, natural disasters, etc. Here you probe deeper into the process or system to identify more precisely the symptoms causing the metric result. This step focuses in on the area of the constraint or opportunity to improve. You should breakdown the metric into its components; identify component data driving the metric trend; differentiate between special and common causes; identify specific areas which are excelling; and recognize the specific areas constraining the process. Exercise caution at this point--resist jumping to a premature solution without thoroughly understanding the problem; focus on recognizing the symptoms and contributing factors.

3. Identify root cause or constraint. Now your objective is to identify the root cause(s) or constraints which underlie the symptoms and hinder the "make or break" activities. Isolate the symptoms to the "make or break" activities in order to identify the most consequential root cause or constraint. There is a difference between symptom and disease. Symptoms will point you in the direction of the disease, i.e., the root cause. Be sure to always treat the disease--not the symptom. Many approaches are available for identifying root causes. One of the most effective tools is a cause-and-effect analysis. There are several techniques including Ishikawa's Fishbone Diagram, Goldratt's Thinking Process, and a simplified composite approach shown in Figure 6-3. Begin with a macro-level view □ to find the constraint C, then take a macro-level view of the components △ comprising that constraint again looking for the constraining factor C at that level and so on ○ ▽ until you uncover the ultimate constraint or root cause RC. Remember to keep a macro perspective at each level.

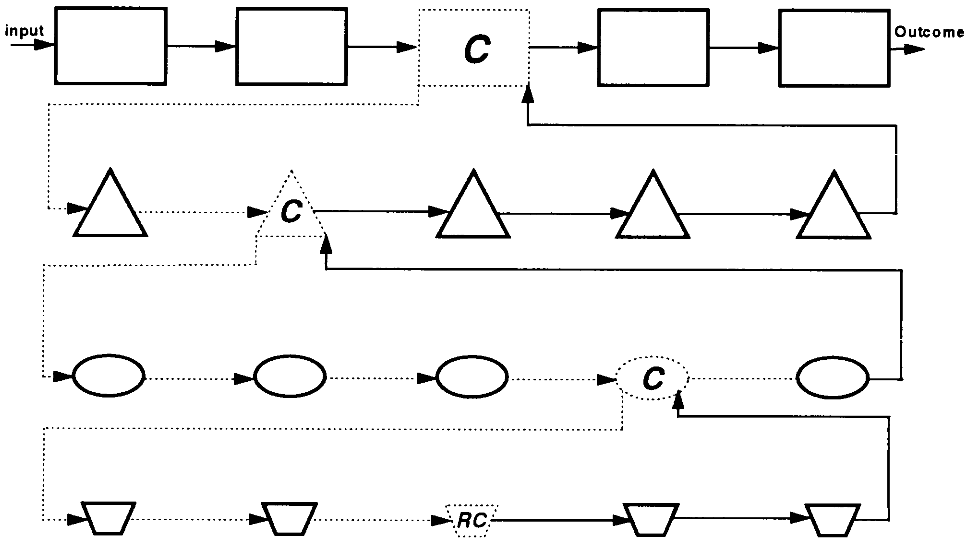

Figure 6-3. Constraint Isolation.

One typical method of locating the constraint or choke point is to discover where inventory or work-in-process is building up (e.g. parts or paperwork stacking up, people waiting for assistance, anything waiting to enter the next activity). Such build-up usually occurs in front of the constraint. Also look for where people or processes are idle or under-utilized because they are waiting for work from an earlier step in the process. This would suggest that the constraint is earlier in the process. The constraint will most often be found between the inventory build up and the idle activity. Any system is not capable, given the current resources and set-up, of producing more than the capacity or capability of the constraint (or weakest link) regardless of the capabilities of the rest of the system, i.e., if the constraint can only handle four customers an hour then the entire system will only be able to service four customers an hour.

When dealing with true constraints (that weak link or bottleneck that is determining/restricting the level of process output), you should deal with only one at a time within a process. Attempting to resolve more than one constraint at a time may result in rework and sub-optimization. One improvement will ripple through the process and may solve (or create/shift) other problems. They may also mask or offset other improvements, thus wasting resources.

4. Improve the process. This step is often the most challenging since there is no "cook book" approach to process improvement. Normally, you'll be faced with one of two situations: the process is basically sound or it is dysfunctional. In the first case, there is localized opportunity for improvement or repair. Once the root cause is identified, the repair is usually fairly straightforward. From there you look for new opportunities to improve. In the second situation, there is a strong potential for complete overhaul. Reengineering may be required when multiple (and serious) deficiencies or inadequacies exist. Exercise caution that your change is not merely for the sake of change and that your solution is cross-functional (in the best interests of the organization as a whole).

Once you've gone through one cycle, you are not done. In order to sustain continuous improvement, you must reiterate the process to find new opportunities to update your improvement strategy.

d. Initiate Action:

Now that you've determined what to improve within the process, you must take the appropriate action to implement it. There are many sources to draw upon in determining an effective action to improve a process. Five valuable sources are the process itself, your customer, your people, your competition, and your competition's customers. A more general source is anyone recognized as the best at what they do or who have established the "best practices" in their field.

If your metrics are effective, you'll never have to ask "Now What?" or "So What?" after an evaluation of your data. Good metrics should indicate where to focus your energies to uncover the "appropriate action" to take. To keep your metric effective, you must dynamically modify and adjust it as you make improvements to your process. You may even find that you need to eliminate a particular metric once that area is no longer considered one of the "vital few" due to your improvements.

As mentioned earlier, benchmarking can be extremely beneficial to an organization. It allows you to draw upon others' successes to improve your processes. More importantly, it allows you to benefit from others' "best practices" so your organization will excel. Benchmarking involves studying other organizations that perform activities similar to the one you are trying to improve and applying their ideas to your process. Don't limit yourself to just studying your competition--good ideas can surface from anywhere.

e. Communicating Your Intentions:

Setting the stage for change within your organization can be as important as actually making the changes. Before taking action, you should clearly explain to your people what you are changing, why you are changing it, and when it will happen. If you have been truly empowering your people, they will be proposing the changes, therefore eliminating many of the barriers to change.

Communication serves two purposes. First, it educates your people. Continuous improvements or, in a few cases, new processes take some getting used to. Education can minimize the time lag from initial introduction, through the learning curve, to integration and acceptance. Second, and more importantly, communication shows your people that you value them as integral to the success of any changed processes and policies. Explaining your actions will minimize resistance to change and maximize your chances for success at implementing change. The degree to which you explain your actions up front will serve to achieve consensus earlier than otherwise possible. Part of the communication exchange includes updating your improvement strategy. Remember to treat your improvement strategy as a dynamic document to communicate what you are doing and where you are headed. In addition it serves as an historical record of how the process evolved, lessons learned, and to avoid repeating past mistakes.

f. Follow-Up:

A continuous improvement philosophy requires the support and commitment of customers, suppliers, and process owners. Consider whether your implemented change has addressed only a symptom instead of the root cause of the problem. Customer satisfaction is the true thermometer of your success. Customer surveys are often viewed as a panacea; they are not the only, nor the best, link to customer satisfaction. Frequent and open communication is paramount--telephone calls, face-to-face contact, group meetings, etc., will pay much greater dividends. Besides, good metrics should be able to anticipate customer satisfaction because of their feedforward nature. You should view customer dissatisfaction and process problems as valuable feedback and incentives to improve the process. In many cases, reward systems will require changes to support customer- and process-oriented behavior--don't punish people for taking the initiative in identifying problem areas.

g. Repeat the Process:

Even now you're not done! Continuous improvement means eternal vigilance. You'll need to continually monitor your processes to determine the success of process changes. At this point you have completed just one cycle of the steps shown in Figure 6-1. You must continually take action based on what your metrics tell you--they are your guide. You do this by repeating the cycle (including the steps in Figure 6-2)--"management by metrics" is an iterative process which requires on-going attention in order to remain dynamic and effective.

Chapter 7: Development Model

a. Introduction:

This chapter provides one method for developing a metric with its supporting measures. There are numerous models or techniques for building metrics; regardless of what procedures you choose, the key is to develop your metrics recognizing the mission (strategic plan)-customer-product-process relationships.

It is important to recognize that metrics are merely a supporting tool for your strategic planning. Process owners' actions must be in harmony with the organization's strategic plan--they must create and/or have a definitive set of plans at each level so everyone knows what they are working towards and how it contributes to the overall organization. Metrics provide the measurement and evaluation of progress towards those strategic plans.

b. The Customer-Product-Process Relationship:

Figure 7-1 represents a "big picture" perspective of an organization in terms of the customer-product-process (CP2) relationships. It illustrates customer groups, their requirements, the different products with their supporting processes, and various external inputs. It is essential you develop such a perspective of your organization to ensure you develop the "right" metrics. "Right" metrics are those which are linked via the strategic plan to the CP2 relationship, otherwise you won't know if your improvements are focusing on the most important customers and products--and what is vital to them.

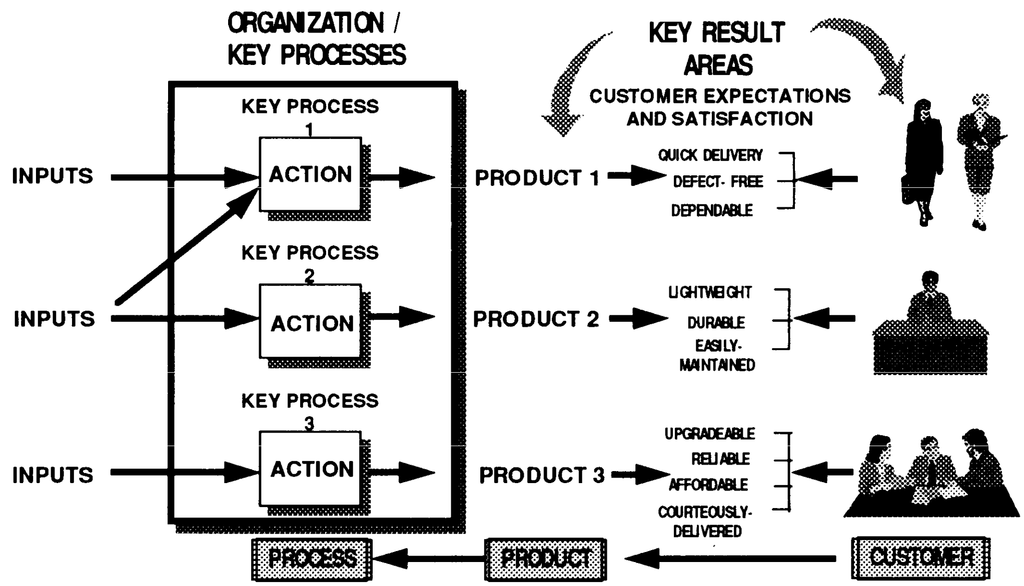

Figure 7-1. Macro View of Organization's Customer-Product-Process Relationships.

First you must determine who your customers are--ultimately your customer expectations drive the "right" metrics. To recognize who your customers are, it may be easier to begin by listing your products; then stratifying into customer groups according to those products. Based on those products, you then identify the supporting process and where the customer first enters that process. It is also important to discern when and where they receive the *complete* product/service they desire/need.

Creating a macro-level flowchart of the process (you have been tasked to develop a metric for) will help you gain an understanding of the process. Ensure the actual process owner and the right stakeholders are involved. You also need to understand any external factors which can impact your process, e.g., suppliers, multiple customer requirements, resource requirements, Congress, or any other thing which provides input to or impacts on your system.

Once you have gained an understanding of your system, i.e., the customer-product-process relationship(s), then (and only then), begin to focus on that *one* customer/product (group) which deserves your *most* attention (as depicted in Figure 7-2). This is referred to as customer/priority stratification.

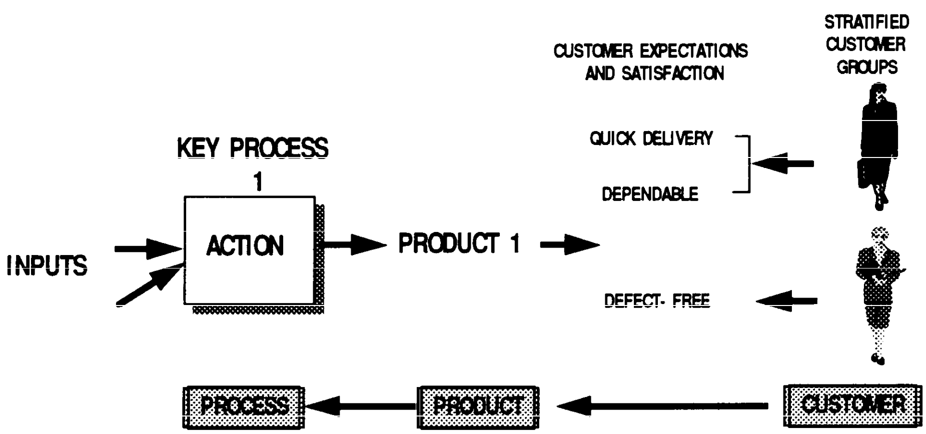

Figure 7-2. Stratified View of the Customer-Product-Process Relationship.

Once you have prioritized our customers, the next level of stratification is based on whether customer groups have different expectations regarding the (same) product. Different requirements will drive different product characteristics or priorities. Most times you will stratify first by customer, and then by product; other times you may find it useful to stratify the products first and then the customers. Ensure that your conclusions are synchronous with your organization's strategic plan!

Metrics development actually starts with each important customer's expectations regarding the product or service. Different metrics may be needed for different customer groups that have significantly different expectations. Each customer group helps define a unique customer-product-process relationship which may warrant separate metrics. Begin the metric development process starting with the most important customer (or if there insignificant differences, the one requiring the more immediate attention). Remember that one of the attributes of a good metric is that the behavior or improvement you are trying to drive is important to the customer. So, it makes sense to base your metrics on a prioritization of customer expectations.

c. Overview of the Model.

Figure 7-3 shows an overview of the process which is comprised of 4 major areas, each having its own supporting steps.[4] The overarching objective of each block is the question immediately above it as shown in Figure 7-3. The model is consistent with the CP2 relationship and focuses in on the "critical few" while achieving continuous Improvement.

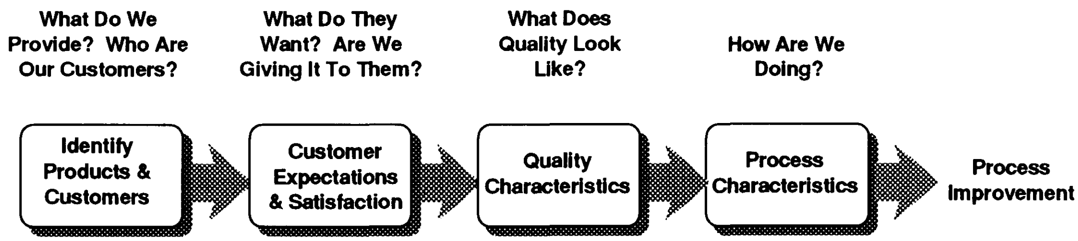

Figure 7-3. A Method For Developing Metrics.

ONE WARNING IS IN ORDER: Exercise caution in using this technique so that you do not proliferate metrics--be sure to focus in on the most important areas first. Attempting to measure "everything" for every customer can be very resource consuming and can quickly obscure the intent of your strategic plans. Bottom Line: Maintain focus on the critical few.

The formality of the mechanics used for this process requires some common sense--take some time to verify what you believe to be "intuitively obvious" is in fact true. The level of detail will depend on the complexity of the organization, the maturity of the process, and where the organization is on the quality journey (with respect to the QAF criteria). How you use this approach depends on your own requirements; it can be used from the ground-up helping to sort out the right customers and product/services or it can be used to focus in on a particular customer or product. Be imaginative--it can apply to any scenario!

d. Step 1:

In the first step of the process (see Figure 7-4), you begin by analyzing and documenting the **"Customer-Product"** portion of the Customer-Product-Process relationship. You want to find out who your customers are and what they expect from you. These steps are supported by a series of worksheets. Worksheet 1, shown in Figure 7-5, helps you answer Steps 1.1 (Define the Product) and 1.2 (Identify and Stratify Customers).

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[4]This model is adapted from the *AFDTC Metrics Course* and *Measuring Quality: Linking Customer Satisfaction to Process Improvement, An AFDTC Supplement to the Air Force Materiel Command Metrics Handbook*, July 1992.

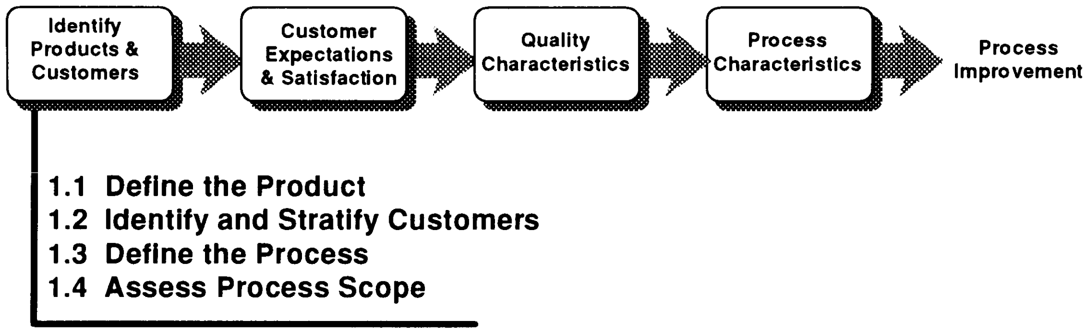


Figure 7-4. Identify Products and Customers.

Using Worksheet 1, list the major products/services your organization provides and their corresponding customer groups. Sometimes it may be easier to recognize different customers and then try to differentiate the products/services you furnish them. Next, decide the relative priority of your product/customer group combinations. Remember when seeking improvements, you want to focus on one area at a time and the most important first! As you "take care of" the most important customers (products), you will most likely be taking care of many of the others too. Also remember that customers are stratified into groups based on whether different customer segments have different expectations regarding the product or service you deliver.

WORKSHEET 1 **Customer Stratification**

Product	Customer Group	Priority/Reason

Figure 7-5. Worksheet 1: Customer Stratification.

Next, you begin addressing Step 1.3--Define the Process. Now that you know the customer/product group, you need to focus on its specific supporting process. Worksheets 2 and 3 will help you gain a detailed understanding of the process. Two warnings: First, do not try to find the solution without going through the whole approach. Second, keep the whole organization in mind to avoid sub-optimization.

Figure 7-6 illustrates that process owners have external influences that they must contend with and that their system/process depend on. They take these inputs and run them through their process and their **outcome** is the product/service they provide to customers. Use this perspective when you build your macro-level flowchart.

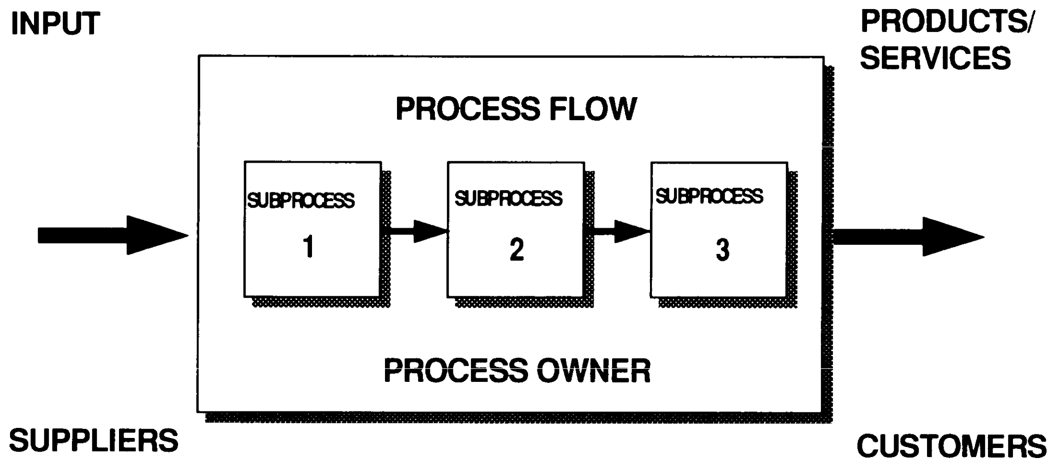


Figure 7-6. Defining the Process.

The following worksheets help you understand the important aspects and task relationships of the process. Figure 7-7 depicts Worksheet 2--you need one of these for each customer and each of their products/services. Begin by identifying the customer, the specific product/service, and a descriptive title for the process that produces it. Then document where the process begins. Take

<u>WORKSHEET 2</u> Process Boundaries

Customer: ______________________________

Product/Service: ______________________________

Process Title: ______________________________

____

____

Process Start Point: ______________________________

____

____

Process End Point: ______________________________

____

____

Figure 7-7. Worksheet 2: Process Boundaries.

into consideration where and how the customer first enters your system or first initiates a desire for your product or service. Also consider where the process receives inputs (e.g., resources, supplies, information, etc.).

The process end point is where the process output (product/service) is passed on to another process or directly to a customer external to your organization. Keep an **outcome** perspective--the process ends when the customer gets the product/service <u>and</u> the necessary support required to keep it functioning as originally intended.

Based on each of the products identified in Worksheet 2, your next task is to chronologically list the <u>major</u> steps of the process--remember to stay at a macro-level. It is not necessary to include feedback loops, decision points, expectations, etc. For each step indicate where it is performed (performed by). This can be a person, position, work group, function, department, etc. Also for each step, list the inputs/outputs to include both physical and informational, i.e., those things you receive from suppliers and the corresponding outputs you produce. Worksheet 3 (Figure 7-8) is designed to help you document this step.

<u>WORKSHEET 3</u> **Process Flow**

Major Step	Performed By	Input/Supplier		Output

Figure 7-8. Worksheet 3: Process Flow.

To fill out Worksheet 3, first identify the major or macro steps in the process. List the first major step in column 1. After that, fill out the "Performed by," "Input/Supplier" and "Output" columns for that step. Note that each major step may have multiple entries for columns 2-4.

Sometimes it helps to recognize that each activity or step in a process serves three roles: supplier, processor and customer. It is a supplier in that it provides input to the next process step, a processor in that it adds value to what was given it by the previous step, and a customer in that it is a recipient of input from the previous process step.

Now you should not only know who your customers are and their respective products, but you should also have a basic understanding of your process. You are now ready to move on to the second step.

e. Step 2:

The second step, shown in Figure 7-9, involves identifying your customers' expectations regarding your product/service and also their level of satisfaction. You must look through your customers' eyes to see how they view your organization's products and services. Here the idea is to ensure you understand exactly what your customers expect from you in terms of the product/service you provide. You then use this information to focus your improvement efforts and your metrics.

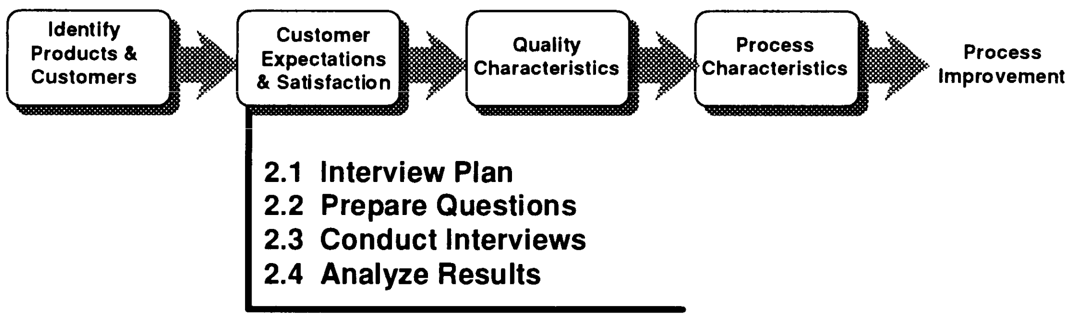


Figure 7-9. Customer Expectations and Satisfaction.

Step 2.1 involves an interview plan. Your goal with the interviews is obviously to find out your customers' expectations regarding your product/service. It is important to take the time to develop a plan. It should include such things as the interview objective (i.e., what is it that you are trying to accomplish), who will be interviewed, who will do the interviewing, what you plan to do with the results, how will the results be analyzed, and a schedule. To create an interview plan you have to consider such things as how many customers you have, where they are located, and how you plan to communicate with them.

Step 2.2 is where you think about and prepare questions before actual interviews with your customers. The driving factor is the need to discover your customers' expectations, requirements, and desires. Keep the questions simple and ensure they focus on limited and specific items. For example, don't ask "Are you satisfied with cost, schedule, and performance?" Instead ask "Are you satisfied with the cost of Product X?" , "Are we delivering it to you when you need it (schedule)?" , etc. Be prepared to lead your customer through this area even to the point where you suggest specific expectations.

Step 2.3 is the actual conduct of the interviews. **Don't rely on surveys!** The point is to facilitate open and honest communication that will lead to doing your job better--this is often hard to do with a boiler-plated survey sent through the mail.

This particular method is based on capturing the *importance* of each expectation to each customer and their degree of *satisfaction* with your performance in that area. Figure 7-10 is one way to quantify your findings. It displays two 6-point Likert scales as tools for capturing the spectrum of a customer's satisfaction and the importance to him/her of a particular product/service. Worksheet 4 (Figure

7-11) is used as an aid to consolidate customer input during the interviews. Prior to the interview, list what you believe to be your customers' expectations in the first column (you give them the opportunity to modify these during the interview). Then during the interview ask the customer to rate the importance and satisfaction in the remaining two columns. The customer's rating should be made using the 6-point Likert scales shown in Figure 7-10. **Don't forget to ask the customer if there are any additional expectations that weren't addressed.** Note that each customer will have their own individual worksheet.

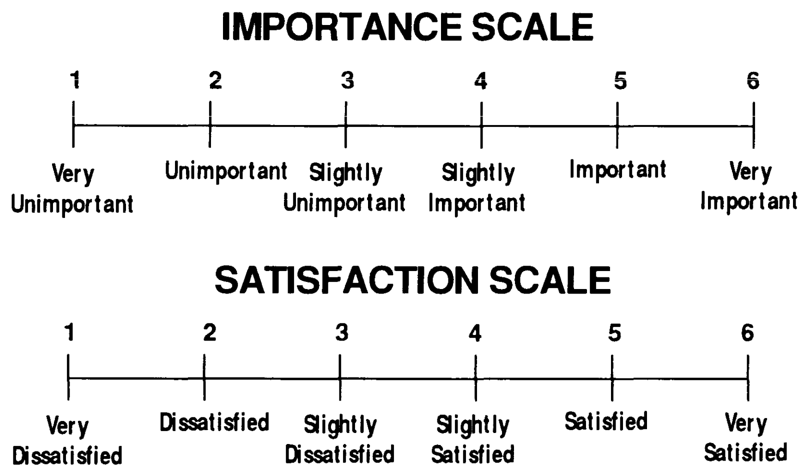


Figure 7-10. Customers Rate Their Expectations.

Begin your interview by telling your customer why you are there and what your objectives are. If you are sincere and open the door for constructive feedback, your customer should be responsive. Don't try to defend the way things are now--rather listen to what they have to say. Not only are you trying to find out what is important, but how is it important--specifically through the eyes of the customer!

As a minimum, your customer's expectations should address such things as cycle time (how long did it take for the customer to receive the product/service after they request it, did the customer get it when they wanted it, is the lead time or turnaround time acceptable), cost (is it reasonable, fair, competitive), quality (is the product/service defect free, is the product reliable, maintainable -- all the "ilities", accurate, complete), customer relations (courteous, knowledgeable, friendly, professional, helpful), etc.

Expectation	Importance	Satisfaction
1		
2		
3		
4		
5		
6		
7		
8		
9		

Figure 7-11. Worksheet 4: Customer Expectations Interview Form.

Your customers may also have suggestions on how to improve the process. If they are measuring your performance, see if they will provide feedback, and if possible, find out how you stack up against the competition. Ask your customer if they know of others who are providing a better product or service and how. Understand the relative priority of each of their expectations and their current level of satisfaction. Often the customer can be a good source of ideas on how to improve.

While these worksheets illustrate this particular method, remember that there are other types of information that you can and should collect during customer interviews. This tool works well in quantifying subjective/qualitative judgments and can be applied to many areas. It also acts as a quick focusing device--however it is not a panacea and won't find the <u>solution</u>. The data can't make the decision for you--the decision comes through your interpretation.

In Step 2.4, you analyze results based on your data collection. Worksheet 5 (Figure 7-12) is used to record the data--you will need one for each expectation. For each Customer group on this worksheet record the totals within each of the first three columns: the number of responses, importance and satisfaction

<u>WORKSHEET 5</u> Expectation Analysis Summary

EXPECTATION TITLE: ____________________

CUSTOMER GROUP	NUMBER RESPONDING	IMPORTANCE SCORE TOTAL	SATISFACTION SCORE TOTAL	MEAN IMPORTANCE (II)	MEAN SATISFACTION (CSI)

Figure 7-12. Worksheet 5: Expectation Analysis Summary.

scores respectively. For each row, divide the total importance score by the total number responding to calculate the mean importance index (II); then divide the total satisfaction score by the total number responding to calculate mean customer satisfaction index (CSI).

CAUTION: Although you compute mean scores for satisfaction and importance, individual results are often as consequential (if not more) than the mean or average of many items--particularly regarding satisfaction. You should give considerable thought to examining individual low scores for greater understanding. It is very easy to be "fine on average" and still have very disgruntled customers. If even one customer is unhappy, you should take the time to find out why! Also be careful about aggregating data so much that any useful meaning is lost.

Worksheet 6 puts the information from Worksheet 5, into pictorial form. Through this worksheet you begin to focus on the "vital few" important areas for improvement and measurements. This tool graphically depicts the relationship of two aspects (importance and satisfaction) for each customer group. The average importance and satisfaction scores from Worksheet 5 form a pair of numbers for each expectation, and are plotted in the opportunity window of Worksheet 6.

<u>WORKSHEET 6</u> The Opportunity Window

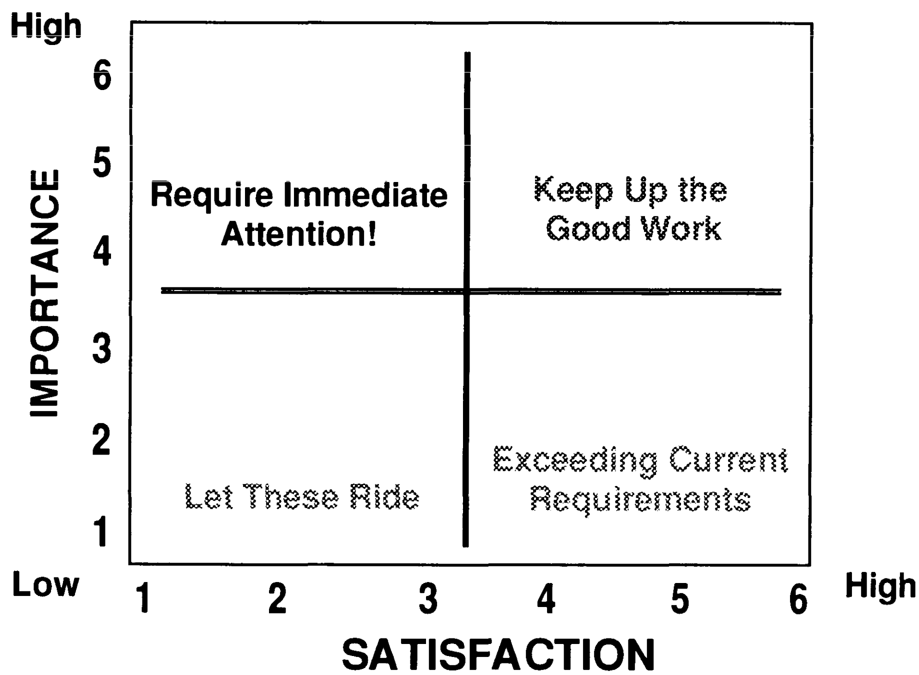


Figure 7-13. Worksheet 6: The Opportunity Window.

Let's examine what the different quadrants of the Opportunity Window represent.

Require Immediate Attention! Data points in this quadrant indicate that you are not satisfying customers or meeting performance expectations in areas that are very important to them. **You must improve in these areas! Work on those nearest the upper left** corner of the quadrant first--where high importance ratings are combined with very low satisfaction scores. Hopefully these will not be too numerous and thus become the "vital few." If there are many, take a hard look at your overall process before going on--you may need to reengineer. If the expectations tend to cluster, go back to your customer for help in prioritizing them.

Keep Up the Good Work. Data points in this quadrant indicate you are satisfactorily meeting customer expectations in areas which are very important to them. Don't become complacent -- still seek improvements, but only after fixing those "Require Immediate Attention" items.

Exceeding Current Requirements. Data points here indicate you are doing well in areas that are not that important to the customer. You may be able to reallocate resources to areas more important to the customer--however be careful! When you start reducing performance in these areas, it may become apparent that the customer had taken the current level of performance for granted and expected it to continue as the norm. When you begin to reduce performance, they may realize that those areas were more important to them than they had thought or indicated. Work closely with the customer to negotiate levels of performance.

Let These Ride. Until you have improved those areas that are important to the customer to a satisfactory level, leave these areas alone. However, in the quality world, you never want your customer to find your performance unsatisfactory--so as resources become available, make the necessary improvements (while working closely with the customer). Poor quality in any area reflects poorly on the organization and may prevent future opportunities.

Now that you know what your customer wants, you need to go back to your strategic plan and ensure your customers' expectations are in harmony with it.

f. Step 3:

Figure 7-14 depicts the next step in the metric development model--identifying "Quality Characteristics." In this step, the vital few expectations identified via the Opportunity Window, are used as a basis for identifying important characteristics of the product/service. In other words, what are the properties or dimensions of the product or service that the customer bases "goodness" on? This step further expands the **"Customer-Product"** relationship by focusing on and documenting how specific customer requirements relate to the product/service quality characteristics.

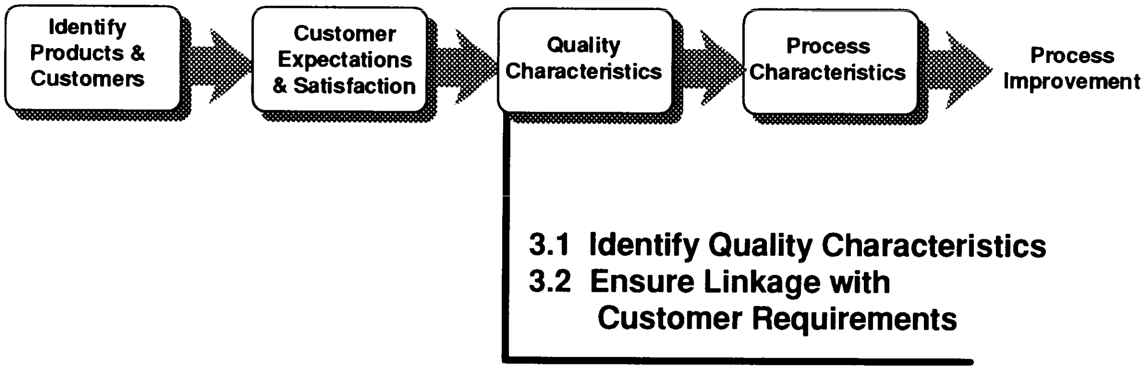


Figure 7-14. Quality Characteristics.

Step 3.1 involves identifying key product/service features that are linked to the vital few customer expectations from the Opportunity Window. For instance, if the Opportunity Window showed that customers report the product/service is not being provided in a timely manner, a quality characteristic for that product/service might be "time to provide the product/service after customer request." Note the link between the quality characteristics and the customer expectation.

To further develop the Customer-Product-Process relationship, you use a tree diagram, and, in this step, fill out the first branches. Worksheet 7 in Figure 7-15 is designed to show the link between the vital few customer expectations identified via the opportunity window, and the specified quality characteristics of the product/service.

<u>WORKSHEET 7</u> **Tree Diagram**

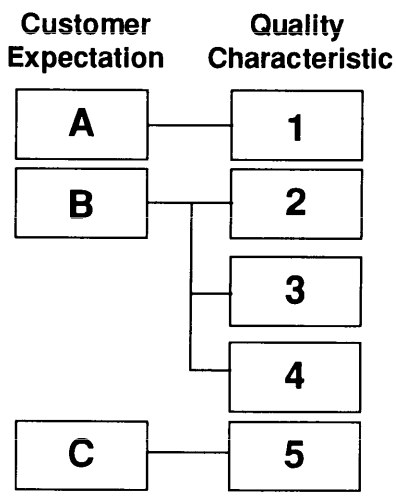


Figure 7-15. Worksheet 7: Tree Diagram (Quality Characteristics).

For each customer expectation, you determine what performance or results will satisfy that particular expectation. Each customer expectation has one or more quality characteristic associated with it. As with customer expectations, quality characteristics are defined by the customer. Quality characteristics are those process results or outcomes which impact customer expectations. They are the characteristics of the product/service that influence what the customer sees or experiences. For example, a customer expectation might be "quality staff summary sheets" (this would be recorded in one of the uppercase alphabetical blocks). This expectation then can be broken down into component quality characteristics that explain or further define a "quality staff summary sheet" (which would be annotated to the linked numeric blocks). These could include: without error, timely, communicates.

In another example, consider the manufacture of coffee cups or mugs. As you've talked to various customers, you've realized that you have two different groups with different expectations. So you've stratified your customers into two groups: coffee drinkers and coffee cup collectors. The quality characteristics associated with the coffee drinkers are more functionally oriented--e.g., size, thermal qualities, stability (for use in the car), etc. On the other hand, the quality characteristics of the collectors center on cosmetics--e.g., design, colors, logos, etc. Each customer group then is different and causes you to look differently at how you will satisfy them.

In this step, you have begun to define more precisely what it is about your product or service that is important to your customers. This includes such things as how it looks, how it performs, how long it takes you to provide a service, etc. Thus, a clear linkage is established between customer expectations and actual characteristics required to meet them. The next step is designed to help you focus even more precisely--now you examine where in your process those quality characteristics are affected.

g. Step 4:

In the final step (see Figure 7-16), you turn your attention to the inner-workings of the process, i.e., "Process Characteristics." In this block, you must identify key characteristics of the process that are linked to the quality characteristics of the product/service, which, in turn, are linked to the vital customer expectations.

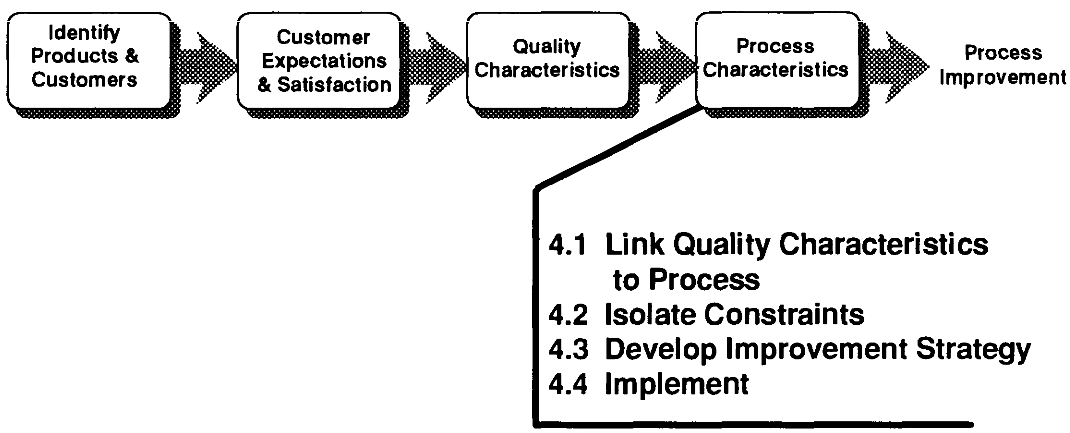


Figure 7-16. Process Characteristics.

At this point in the development process, you should have the **Customer-Product** linkage specified and now you need to recognize the **Process** contribution to the relationship. In a nutshell, you now move inside your organization to see how "what you do" determines the product quality and ultimately customer satisfaction.

To begin Step 4.1, you need to further understand your process--refer back to Worksheet 3 (Figure 7-8) as a source. Also, a flowchart is a very useful tool (see Figure 7-17); remember it is imperative to keep the process flowchart at a macro-level (recommend 10 boxes or less). The actual symbols used to depict the process is relatively unimportant (its your prerogative to determine the level of formality)--keep it simple so you can focus on the relationships between the activities. Expansion of the flowchart maybe required later, but remember the level of detail and the breadth and depth of the process to be flowcharted depend on how far you must go to gain adequate insight on process characteristics. Don't flowchart the whole process if you don't have to!

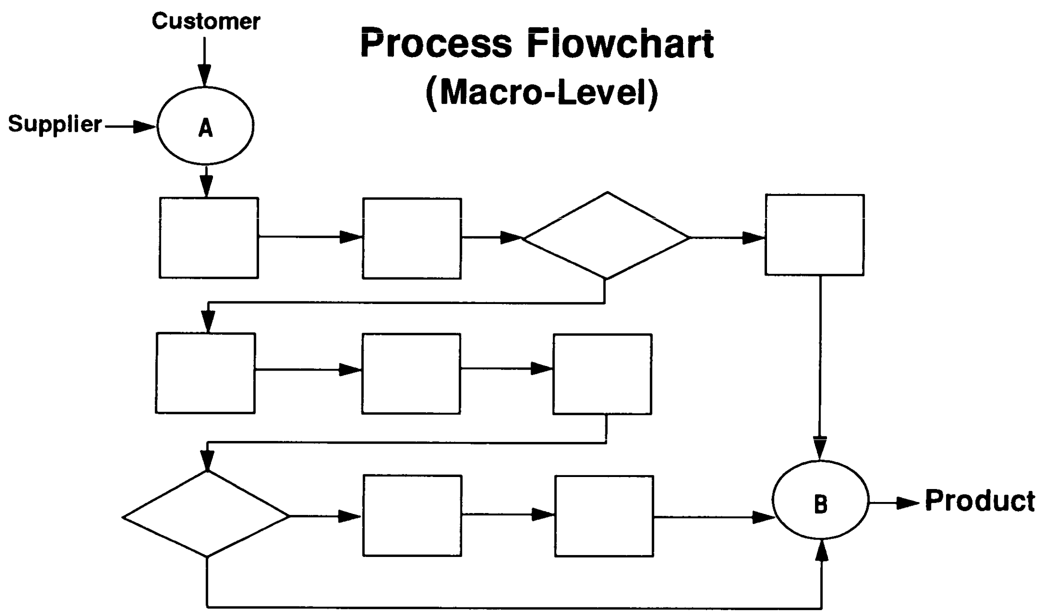


Figure 7-17. Process Flowchart.

Worksheet 7 (see Figure 7-18) is now completed by using your knowledge of the process (gained in the flowcharting step) to identify the *process characteristics* which impact their respective quality characteristics. In short, what is that you do in the process that affects the quality characteristic(s)? After completion, it illustrates the full linkage of each customer expectation to quality characteristics to process characteristics. Continue developing the tree in Worksheet 7 by linking process characteristics from the macro-level flowchart (or Worksheet 3) to their respective quality characteristics. Link them using the appropriate lower-case alphabetic blocks in Worksheet 7. Ask yourself: "What parts or operations of the process have the most effect on the outcome of the quality characteristics?" and " What portions of the process must we do more efficiently to improve outcomes (effectiveness)?"

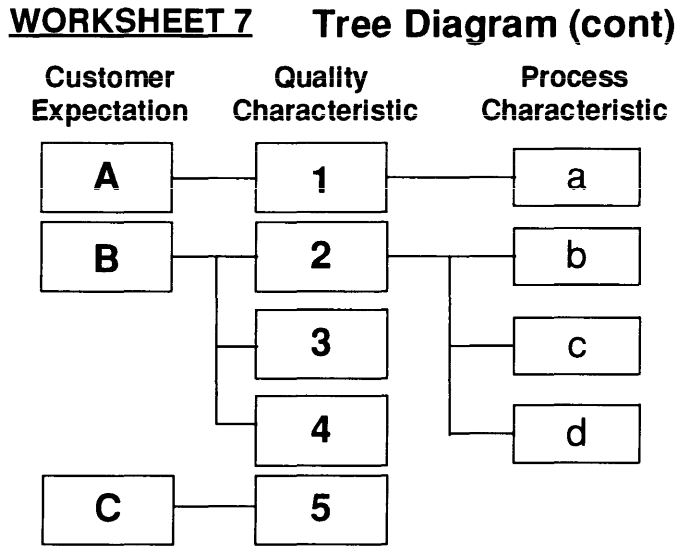


Figure 7-18. Worksheet 7: Tree Diagram (Process Characteristics).

Completing the flowchart and determining process characteristics can become interactive--a "chicken-or-egg" situation. If you have difficulty developing your flowchart, ask yourself what process characteristics contribute to the quality of the product/service. Returning to the staff summary sheet example, process characteristics that affect the quality of a product might include spell checkers in your word processing system, a tracking mechanism to know where the sheets are in the process, format guidelines that everyone can follow, etc. Identifying these may also help identify your process steps.

Another example is the coffee cup illustration. Remember there were two customer groups--coffee drinkers and collectors. One expectation of coffee drinkers, expressed in terms of a quality characteristic, is that the cup have good thermal properties, i.e., it keeps the coffee hot, but doesn't scald the user when he/she holds it. Possible process characteristics affecting thermal properties may then be type of material, thickness of the cup, etc. Collectors, on the other hand, may care nothing about thermal characteristics. They may want bright colors and unique designs. Possible process characteristics affecting those quality characteristics might be the type of glaze used, the type of material, etc.

One quality characteristic may have many process characteristics comprised of one or more tasks or operations within the process. To best use your resources and get the most immediate impact, you want to first focus your attention on the constraints or bottlenecks within the process. Figure 7-19 offers one approach.

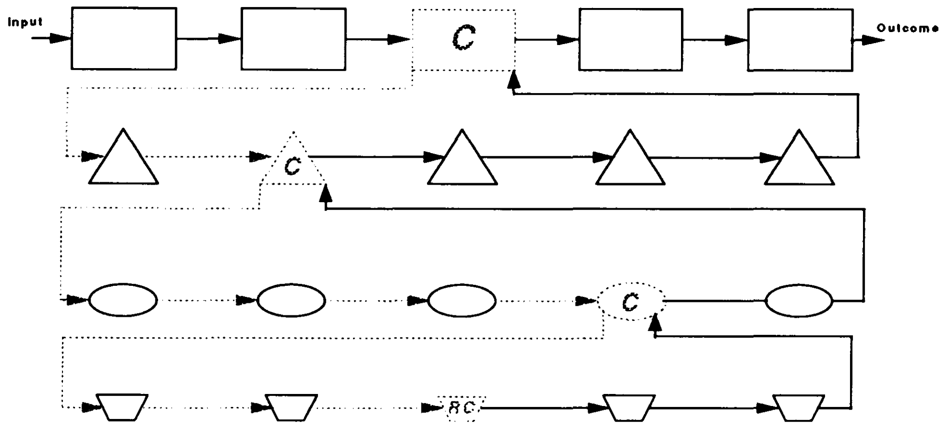


Figure 7-19. Isolating the Constraint.

Here in Step 4.2, you focus on identifying root causes or constraints which underlie the symptoms and hinder the "make or break" activities (this concept is also discussed in Chapter 6.) You want to isolate the symptoms related to the "make or break" activities in order to identify the most consequential root cause or constraint. There is a difference between symptom and disease. Symptoms should point you in the direction of the disease, i.e., root cause. Be sure to always treat the disease--not the symptom. Many approaches are available for identifying root causes. One of the most effective tools is a cause-and-effect analysis, e.g., Theory of Constraints and fishbone diagrams. Begin with a macro-level view to find the constraint C, then take a macro-level view of the components comprising that constraint again looking for the constraining factor C at that level and so on until you uncover the ultimate constraint or root cause RC.

At this point you have identified the constraint that becomes the focus of improvement activities. Additionally you must decide what are the "critical few"--those key tasks and activities that "make or break" the process or indicate the process' overall outcome success. Continue to monitor these multiple points and ensure you avoid sub-optimization. Large complex systems may require simultaneous improvements for independent activities. Don't confuse quality deficiencies and throughput (output) constraints--some customer expectations may have nothing to do with throughput. Improving quality is important even though output doesn't increase. For example, you may deliver a top-notch product that the customer loves, but the customer dislikes your customer relations/rapport (e.g., professionalism, attitudes, knowledge, etc.). As you improve productivity, you can simultaneously make other quality improvements.

When dealing with true constraints (that weak link or bottleneck that is determining/restricting the level of process output), you should deal with only one at a time within a process. Attempting to resolve more than one constraint at a time may result in rework and sub-optimization. One improvement will ripple through the process and solve (or create/shift) other problems. They may also mask or offset other improvements, thus wasting resources. Guard against sub-optimization and remember that the true constraint determines the system output--be aware of resource tradeoffs.

In Step 4.3 you develop your improvement strategy. Once you have focused in on the vital areas of your process that are associated with the **quality** characteristics, Worksheet 8 (Figure 7-20) can be used to aid in identifying ***process*** characteristics.

WORKSHEET 8 **Process Flow Analysis**

Process Point	Variation Sources	Potential Measure

Figure 7-20. Worksheet 8: Process Flow Analysis.

In the first column of Worksheet 8, list the process points which you identified as constraints and/or as the critical few. In the second column, list those factors associated with that process point which will likely cause variation in the **quality** characteristic of the product/service. These can be used later in process improvement. In the third column, list potential measures for each process point, this could be cycle time, rate of return, cost per unit, defects per unit, but they must be related to the **quality** characteristics previously identified. These potential measures become candidates for **process** characteristics. For instance, if a quality characteristic of the product/service is "time to provide the product/service after the customer requests it," a process characteristic might be the "time to complete one of the time-crucial process steps."

To summarize, you identify those areas of the process most related to the quality characteristics you previously designated. Next, you find the major sources of variation for that quality characteristic associated with each process point. Then you identify potential measures for each process point, related to those quality characteristics. From these you determine your key process characteristics which need your immediate attention. Remember you may need more the one measurement to monitor constraints, but to maintain an **outcome** perspective you must have a metric which illustrates the health of the system as a whole; otherwise you could start sub-optimizing your system.

Now you are ready to complete the operational definition (Figure 7-21)--refer to Attachment 1 for format and definitions. You begin by taking the potential measures identified in Worksheet 8 and refining them into metrics and documenting in Worksheet 9 how you are going to manage by and/or improve. The key is to document a strategy--what and how you intend to improve your process. For metrics to be effective, you must keep the improvement strategy dynamic and use it as a direct part of your day-to-day operations.

WORKSHEET 9 Metric's Operational Definition

DESCRIPTION:
PURPOSE:
DESIRED OUTCOME:
LINKAGE:
PROCESS OWNER:
CUSTOMER:
POPULATION:
FREQUENCY:
SOURCE:
EQUATIONS:
KEY TERMS:
GRAPHIC PRESENTATION:
IMPROVEMENT STRATEGY:

Figure 7-21. Worksheet 9: Operational Definition.

You may have to have multiple measures to monitor improvements for **process efficiencies, customer effectiveness (satisfaction), and an overall view** of the system's **outcome success.** In other words, you may need more than one metric and operational definition--these may center on the customer, on quality characteristics, and on process characteristics. If you do have several metrics associated with your improvement strategy, ensure that you also have one overarching operational definition and improvement strategy that ties the pieces together. Figure 7-22 illustrates the concept.

WORKSHEET 9 Operational Definition:

Date:

Title: Process Improvement "Metric"

	Measurement 1	Measurement 2 . . .	Measurement X
Measurement Description:	xxx	xxx	xxx
Purpose:	xxx	xxx	xxx
Desired Outcome:	xxx	xxx	xxx
Linkage:	xxx	xxx	xxx
Process Owner:	xxx	xxx	xxx
Customer (s):	xxx	xxx	xxx
Population:	xxx	xxx	xxx
Frequency:	xxx	xxx	xxx
Source of Data:	xxx	xxx	xxx
Equations:	xxx	xxx	xxx
Key Terms:	xxx	xxx	xxx
Graphic Presentation:	xxx	xxx	xxx
Improvement Strategy:		XXX	

Figure 7-22. Overarching Operational Definition.

Hopefully you now recognize the importance and relationship of the CP2. Remember your strategic plan (formal or informal) is the basis for what you want to accomplish. Then you figure out how you are going to accomplish your plan by first identifying/prioritizing your **customer**s, the **product**s/services they receive, and those **process**es you use to produce them.

Figure 7-23 depicts the relationship linkages within the CP2 and the resulting system of metrics. You must use your customers' requirements and expectations to define quality--always within the context of your mission. Once you understand your mission requirements, your customer needs, their relationships to your products, and understand how your processes can support them, then and only then can you start making the right improvements. Recognizing how your customers view quality (their expectations), the relationship to the product, and how your process contributes, you now want to improve. As you improve the right elements of your process, you improve the **process characteristics,** hence your product and its **quality characteristics** will also improve, and ultimately your customer will be happier and thus **customer satisfaction** improves.

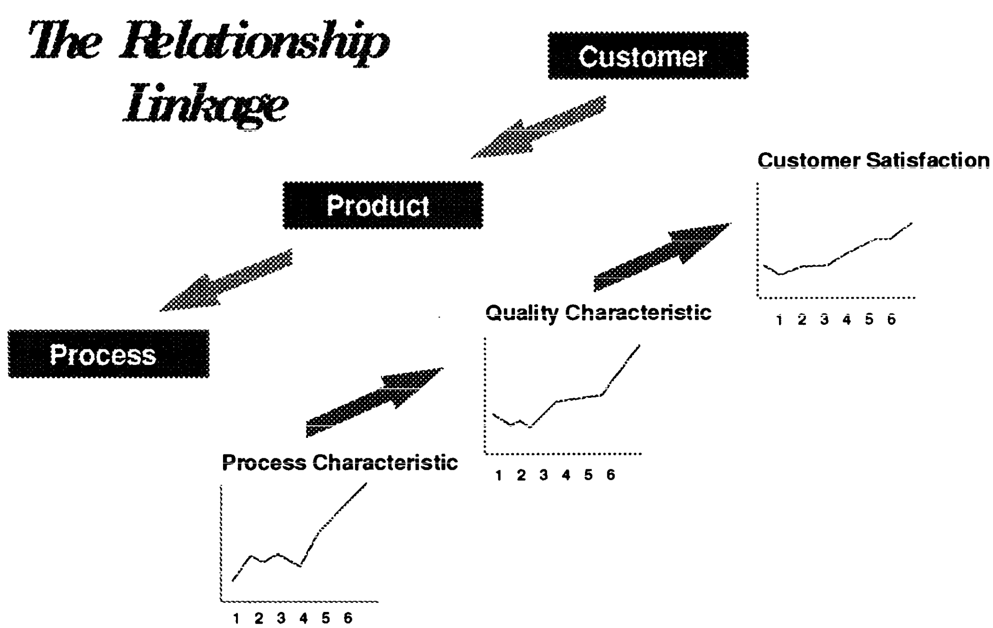


Figure 7-23. The Relationship Linkage--A System of Metrics.

Bottomline--Use your strategic plan to keep the overall right focus, use the CP2 relationship to make the right improvements, and use an outcome perspective to measure the right way.

Once you have developed your metric and improvement strategy, you put them to work (Step 4.4). Remember, to keep a metric effective you use an iterative, on-going evaluation cycle as depicted in Figure 7-24. The iterative approach shown in Figure 7-24 is discussed in detail in Chapter 6. As you improve, you re-evaluate to support sustained continuous improvement.

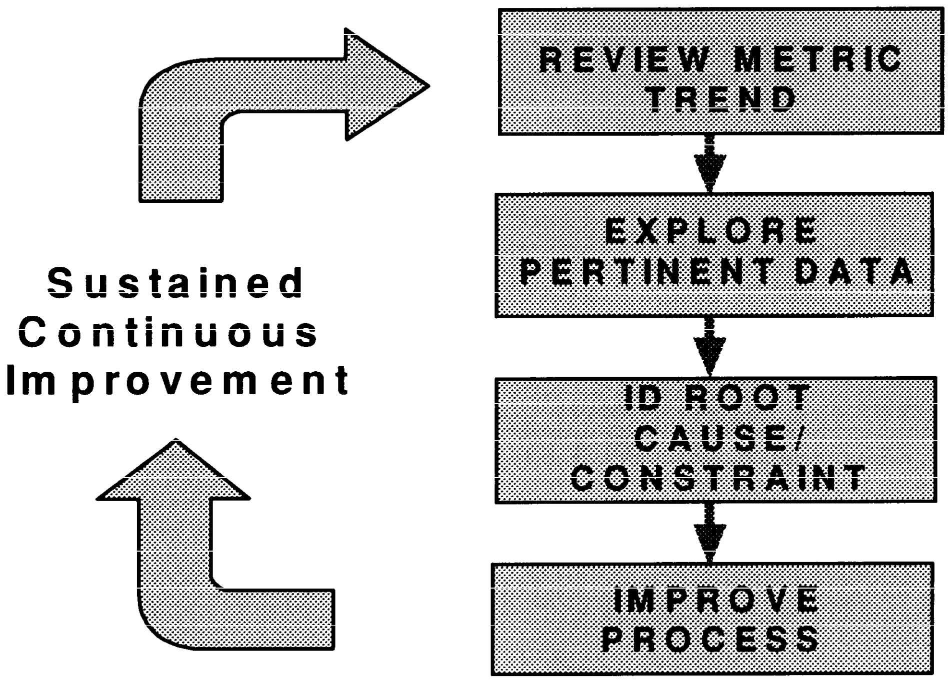


Figure 7-24. Management By Metrics.

EUGENE L. TATTINI
Major General, USAF
Director of Plans

4 Attachments
1. Operational Definition: Sample Format
2. Twelve Quality Tools
3. Glossary
4. References

OPERATIONAL DEFINITION
SAMPLE FORMAT

DESCRIPTION: An unambiguous description of what the metric measures.

PURPOSE: What you are trying to improve.

DESIRED OUTCOME: The change in behavior that will occur if the performance measured by the metric improves. Express in terms of a positive or negative trend (not a numeric goal).

LINKAGE: The link between the process being measured, your organization's strategic plan, and the command goals.

PROCESS OWNER: The accountable process owner.

CUSTOMER: The customer supported by the process.

POPULATION: The population that the metric will include.

FREQUENCY: The frequency of measurement.

SOURCE: The source of the data.

EQUATIONS: Any equations required in doing the measurement.

KEY TERMS: Precise definitions of key terms.

GRAPHIC PRESENTATION: A description of the graphic presentation that will eventually be used to display the data.

IMPROVEMENT STRATEGY: Document continuous improvement philosophy for the metric. Include what actions are being taken to achieve improvement, evaluations of progress and what behavior is desired. Should provide historical record of improvement actions, lessons learned and results. Reference the operational definition presented earlier in the course and in the Metrics Handbook. The key here is to document a strategy--what and how you intend to improve your process. For metrics to be effective, you must keep the improvement strategy dynamic and use it as a direct part of your day-to-day operations. You may have to have multiple measures to monitor improvements for process efficiencies, customer effectiveness (satisfaction), and an overall view of the system's outcome success.

Twelve Measurement Tools

Run Chart

What It Is:

A run chart is a graph of process measurement over time. Its purpose is to:

- Provide first-look, exploratory analysis so you can begin to recognize the basic characteristics, including variability, of a process over time.
- Plot historical data to get a better understanding of what has happened in the past.

How To Use It:

- Construct the chart. Label the vertical axis with the key measurement of the process being measured. Label the horizontal axis with units of time.
- Collect the data and plot them on the chart.
- Interpret the chart using your best judgment. Look for runs of data points that indicate a trend, look for indications of time-related behavior (such as seasonality), and get an idea of how much performance has varied over time.
- Calculation of descriptive statistics such as mean and standard deviation can also lend insights.

Points to Remember:

- For ease of interpretation, approximately the same time interval should occur between measurements.
- Not every variation in the data is significant. Since the factors that make up a process vary over time, any measurement coming from the process will also probably vary. Investigating every variation as though it is critical can be frustrating and wasteful.
- You should keep in mind that it is appropriate to start a run chart with a limited amount of data or a limited number of time periods. You should, however, consider findings from this initial data as preliminary.

Run Chart Example 1:

AEDC collected statistics on data deliverables over the past five quarters to determine if a trend was forming.

TABLE A2-1.
AEDC DATA DELIVERABLES.

Quarter	% Of Data Delivered On Time
FY93/4	48%
FY94/1	49%
FY94/2	73%
FY94/3	77%
FY94/4	94%

Simple Average 68%

Figure A2-1 displays these statistics on a run chart. It appears that there is an improvement trend in this process. Remember this is a preliminary look--more data or shorter time periods between data points may offer greater insights. Don't let "too few data points" be an excuse for not doing exploratory analysis.

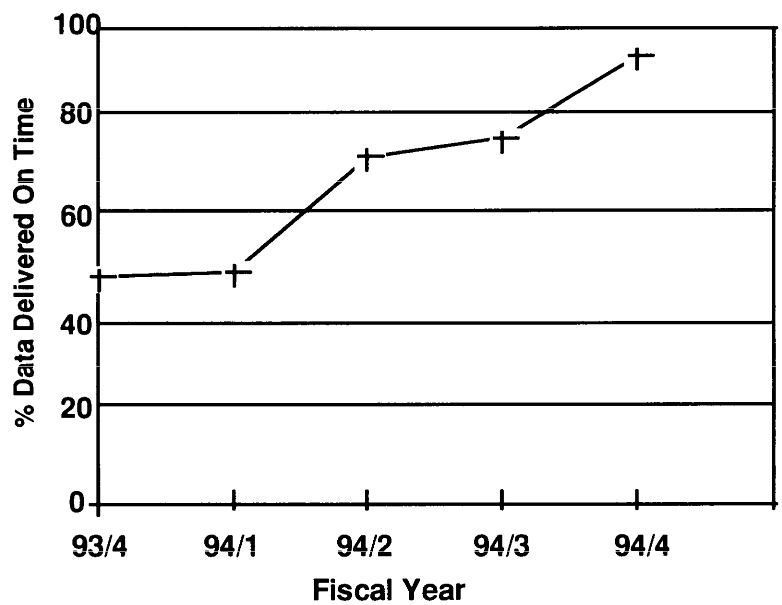


Figure A2-1. Data Deliverables Run Chart.

Run Chart Example 2:

HSD collected data over a 20 month period, taking samples every other month. The following data resulted.

TABLE A2-2.
HSD TECHNICAL REPORT PROCESSING TIME.

Month Sampled	Median Technical Report Processing Time (In Days)
Jul	250
Sep	260
Nov	258
Jan	224
Mar	341
May	290
Jul	196
Sep	158
Nov	165
Jan	173
Mar	144

Simple Average 224 Days of Median Days

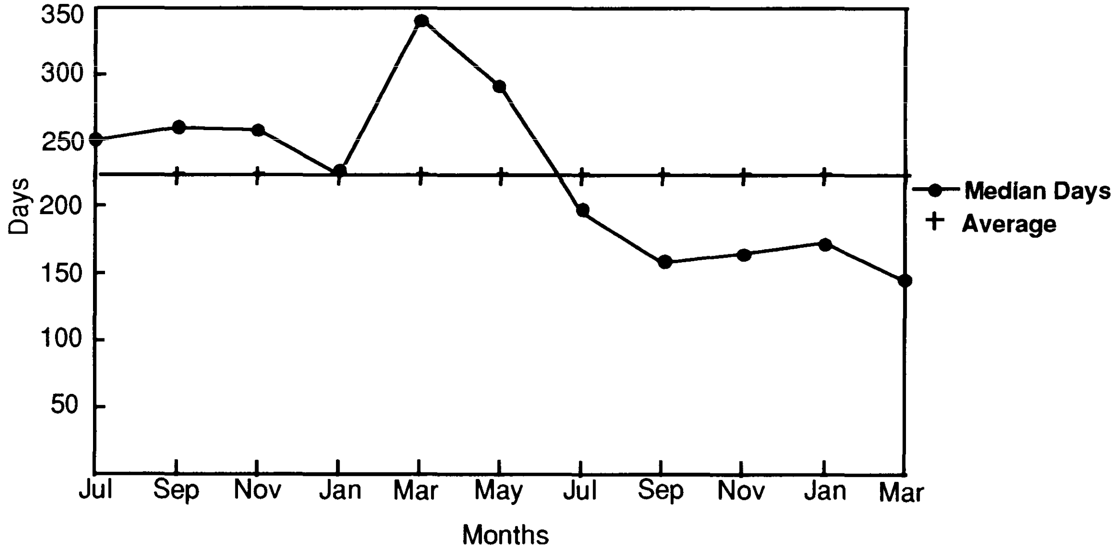


Figure A2-2. Technical Report Processing Time Run Chart.

The run chart shows what appears to be a favorable trend. This apparent trend should be analyzed before basing any decisions on this information.

Control Chart

What It Is:

A control chart is a tool for monitoring the variability of a process over time. A process is in a state of "statistical control" when the variation in the process is consistently random and within predicable limits. When a process is in this state, process measurements vary randomly between an upper boundary and a lower boundary that reflect typical performance limits over time.

Control limits and customer requirements are not the same. Control limits are computed from the actual performance of the process, while the customer specifies and negotiates requirements with the process owner.

A control chart can help a group or individual:

- Understand and recognize variability and when to investigate special circumstances.
- Identify the presence of "special causes" of variation or changes in performance of a process.
- Stop trying to "fix" a process that is varying consistently over time and objectively determine the root causes of problems, e.g., a shift in the process average, change in the variance, cyclic behavior, etc.

Caution:

Control charts should *not* be the *first* tool used to analyze data. The technique is very data-intensive; you must ensure you have the proper sample size to correctly compute the right $\overline{X}$, UCL, LCL. Remember also that control charts were originally developed to *prevent* change in the process so that a consistent product could be produced over and over. Your focus needs to be on *improving* the process--shifting the performance mean and/or reducing variance. *Deliberate process improvement is a "special cause" in terms of control charts!* Improvement efforts will typically involve identifying and improving the effects of "common causes"--which are not a concern in the control chart technique.

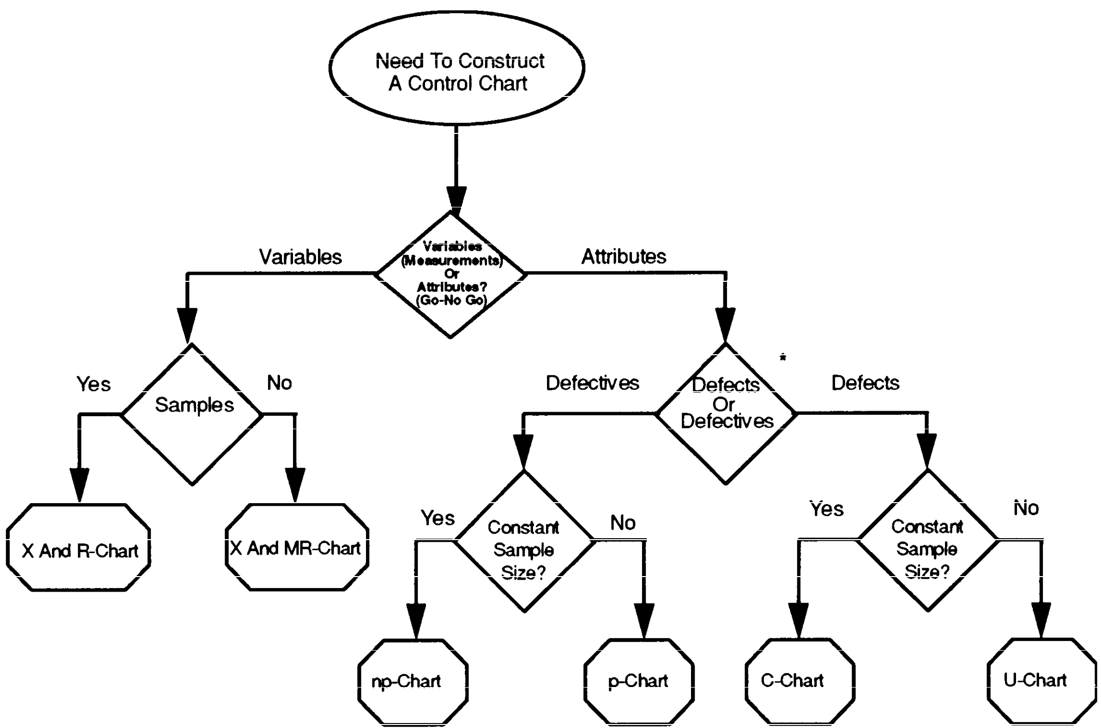
How To Use It:

- The type of data you collect will dictate the type of control chart to use. In general, "variables" data requires some form of measurement (e.g., length, temperature, etc.) and the recording of those measurements. "Attributes" data requires a "good/bad" or "go/no-go" decision and counting, e.g., types of defects, percent late, etc. Since attributes data doesn't require detailed measurements, it is easier and less costly to obtain. Use Figure A2-3 to determine the type of control chart needed.
- Once you determine the type of data to collect, follow the appropriate chart construction techniques on the following pages.

- Determine and eliminate special causes of variation. One or more of the following seven signals indicates the existence of this type of cause:
    - — One or more points outside the control limits.
    - — Seven or more consecutive points on one side of the centerline.
    - — Six points in a row steadily increasing or decreasing.
    - — Fourteen points alternating up and down.
    - — Two out of three points in a row in the outer third of the control region.
    - — Fifteen points in a row within the center third of the control region.
    - — Eight points on both sides of the center line with none in the center third of the control region.

    NOTE: The probability that any of these seven events will occur at random is very small, which is why they are a signal that something has changed in your process.

- When you have eliminated all special causes, work on reducing the remaining variability in your process. You can usually achieve this through fundamental changes to the process, and these changes require management assistance. To achieve continuous process improvement, it's essential to reduce variability.



* Defect = An Individual Failure To Meet A Single Requirement
Defective = A Unit That Contains One Or More Defects

Figure A2-3. Control Chart Selection Process.

Construction Steps

General:

1. Determine the type of data you are collecting. Then consult Figure A2-3 to determine the appropriate type of control chart to employ.

2. Collect the data.

3. Label the vertical (y) axis with the name of the variable measured and its unit of measurement.

4. Label the horizontal (x) axis with units of time.

5. Label the chart with descriptive titles which describe the measurement and its time frame.

6. Determine the sub-groups; calculate upper and lower control limits and mean as appropriate.

7. Divide and label the horizontal and vertical axes into increments which easily allow all the data to be plotted.

8. Plot the data points and the control limits.

Chart Construction Techniques:

$\overline{X}$ and R Chart:

1. You will analyze the ranges (R) chart first, then the sample averages ($\overline{X}$).

2. Compute the range R for each subgroup, where $R = X_{max} - X_{min}$.

3. Scale the lower portion of the chart and plot the points.

4. Compute the average range ($\overline{R}$), where $\overline{R} = (R_1 + R_2 + \cdots + R_k)/k$ = ______.

5. Select A_2, D_3 and D_4 from the table below based on your subgroup size.

TABLE A2-3.
CONTROL CHART CONSTANTS.

Subgroup Size	A_2	D_3	D_4	Subgroup Size	A_2	D_3	D_4
2	1.8880	0	3.267	6	0.483	0	2.004
3	1.023	0	2.574	7	0.419	0.076	1.924
4	0.729	0	2.282	8	0.373	0.136	1.864
5	0.577	0	2.114	9	0.337	0.184	1.816
				10	0.308	0.223	1.777

6. Compute $UCL_R = D_4 \times \overline{R}$ = ______ x ______ = _______

7. Compute $LCL_R = D_3 \times \overline{R}$ = ______ x ______ = _______

8. Draw the control lines and check for any points out-of-control. Recompute the control limits, if necessary.

9. Compute $\overline{X}$ for each subgroup.

10. Scale the upper portion of the chart and plot the points.

11. Compute $\overline{\overline{X}} = (\overline{X}_1 + \overline{X}_2 + \cdots + \overline{X}_k)/k$ = ______

12. Compute $UCL_{\overline{x}} = \overline{\overline{X}} + (A_2 \times \overline{R})$ = ______ + (______ x ______) = _______

13. Compute $LCL_{\overline{x}} = \overline{\overline{X}} - (A_2 \times \overline{R})$ = ______ - (______ x ______) = _______

14. Draw the control lines and check for any points out of control. Recompute the control lines on both charts, if necessary.

X and MR Control Chart:

1. You will construct the moving range (MR) chart first then the individuals (X).

2. Compute MR for each subgroup. MR is the absolute value of the difference between consecutive range values. $MR = R_k - R_{k-1}$ where k and k-1 are consecutive observations. Remember there is no MR associated with the first X value.

3. Scale the lower portion of the chart and plot the MR points. Remember to start at the second position along the time axis.

4. Compute $\overline{MR} = (MR_1 + MR_2 + \cdots + MR_{k-1})/(k-1) =$ ______

5. Compute $UCL_{MR} = 3.268 \times \overline{MR} = 3.268 \times$ ______ = _______

   Note: $LCL_{MR} = 0$

6. Draw the control lines and check for any points out-of-control. If a point is out-of-control, investigate the associated X value. If the X value is removed as abnormal, remember that one MR will be removed and another will change. Recompute the control limits, if necessary.

7. Scale the upper portion of the chart and plot the X points.

8. Compute $\overline{X} = (X_1 + X_2 + \cdots + X_k)/k =$ ______

9. Compute $UCL_X = \overline{X} + 3 \times (\overline{MR}/1.128))$
   = ______ + (3 x (______/1.128)) = _______

10. Compute $LCL_X = \overline{X} - 3 \times (\overline{MR}/1.128))$
    = ______ + (3 x (______/1.128)) = _______

11. Draw the control lines and check for any points out of control. Recompute the control lines on both charts, if necessary.

Attributes Control Chart:

- Determine which chart to use. The information in Table A2-4 will help clarify the options in Figure A2-3.

  Defect: An individual failure to meet a single requirement.

  Defective: A unit containing one or more defects.

TABLE A2-4.
ATTRIBUTES CONTROL CHART SELECTION GRID.

	Varying Sample size	**Constant Sample Size**
Defectives	$\overline{p}$- Chart Used to chart the fraction or percent defective	$n\overline{p}$- Chart Used to chart the number of defectives in a subgroup
Defects	U- Chart Used to chart the number of defects per unit	C- Chart Used to chart the number of defects in a subgroup

- Collect 10-20 subgroups of data. Each subgroup consists of multiple data points arranged in a rational manner, day, lot, office, etc. The value "n" represents the size of each subgroup.

- Use the general construction steps from above with the following formulas:

p-Chart:

n = size of subgroup

$$p = \frac{\text{number of defectives in a subgroup}}{n} = \text{fraction or percent defective}$$

$$\bar{p} = \frac{\text{total defective}}{\text{total inspected}} = \text{centerline} = \text{average fraction defective}$$

$$UCL = \bar{p} + 3 * \sqrt{\frac{\bar{p}(1-\bar{p})}{n}} = \text{upper control limit (varies by subgroup)}$$

$$LCL = \bar{p} - 3 * \sqrt{\frac{\bar{p}(1-\bar{p})}{n}} = \text{lower control limit (varies by subgroup)}$$

Note: You can use an average subgroup size to obtain a single set of control limits if:

- The largest subgroup size is less than twice the average subgroup size.
- The smallest subgroup size is more than half the average subgroup size.

Plot p for each subgroup.

np Chart:

$\bar{p}$, n = same as for p-chart, except n must be constant.

$n\bar{p}$ = centerline = average number of defectives

$$UCL = n\bar{p} + 3 * \sqrt{n\bar{p}(1-\bar{p})}$$

$$LCL = n\bar{p} - 3 * \sqrt{n\bar{p}(1-\bar{p})}$$

Plot np for each subgroup.

u Chart:

$$u = \frac{\text{number of defects per subgroup}}{\text{number of units per subgroup}} = \frac{c}{n}$$

$$\bar{u} = \frac{\text{total number of defects for all subgroups}}{\text{total inspected}} = \text{centerline}$$

$$UCL = \bar{u} + 3^* \sqrt{\frac{\bar{u}}{n}}$$

$$LCL = \bar{u} - 3^* \sqrt{\frac{\bar{u}}{n}}$$

Plot u for each subgroup

c Chart:

c = number of defects per subgroup

$$\bar{C} = \frac{\text{total defects}}{\text{total number of subgroups}} = \text{centerline}$$

$$UCL = \bar{C} + 3^* \sqrt{\bar{C}}$$

$$LCL = \bar{C} - 3^* \sqrt{\bar{C}}$$

Plot c for each subgroup

Control Chart - Example 1:

$\overline{X}$ and R Chart

TABLE A2-5.
$\overline{X}$ AND R CHART DATA.

$\overline{\overline{X}} = 4.37$

$\overline{R} = 0.34$

$n = 5$

$A_2 = 0.577$

$D_3 = 0$

$D_4 = 2.114$

Week	Mon.	Tues.	Wed.	Thurs.	Fri.	X	R
1	4.50	4.60	4.50	4.40	4.40	4.48	0.2
2	4.60	4.50	4.40	4.30	4.10	4.38	0.5
3	4.60	4.10	4.40	4.40	4.10	4.32	0.5
4	4.40	4.30	4.40	4.20	4.30	4.32	0.2
5	4.30	4.30	4.40	4.20	4.30	4.30	0.2
6	4.60	4.60	4.20	4.50	4.40	4.46	0.4
7	4.10	4.30	4.60	4.50	4.20	4.34	0.5
8	4.50	4.50	4.40	4.60	4.40	4.48	0.2
9	4.40	4.20	4.60	4.60	4.20	4.40	0.4
10	4.20	4.20	4.20	4.50	4.20	4.26	0.3

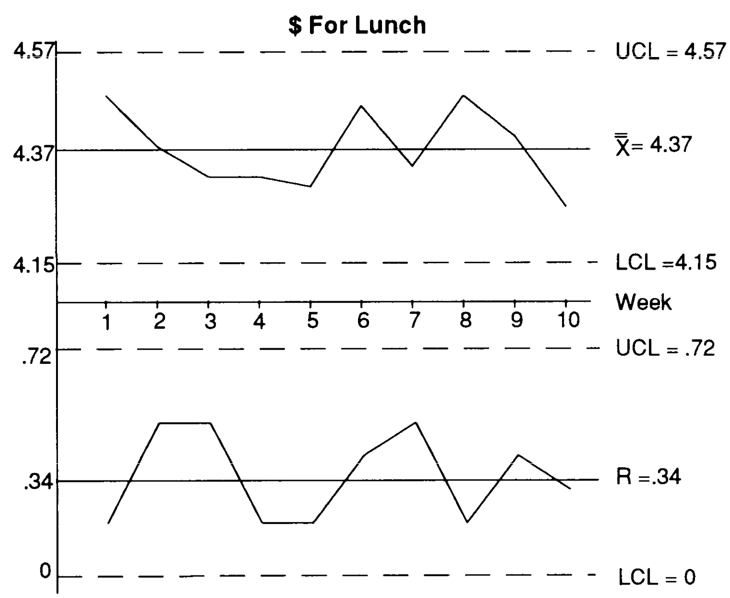


Figure A2-4. $\overline{X}$ and R Control Chart $ For Lunch.

Control Chart - Example 2:

$n\bar{p}$ Chart

TABLE A2-6.
ECPS BOARDED PER WEEK ($N\bar{p}$-CHART).

n=50

$\bar{p} = \frac{46}{500} = 0.092$

$n\bar{p} = 4.6$

UCL=10.73

LCL=0.0

Week	Number Of ECPs Boarded
1	9
2	7
3	4
4	2
5	4
6	5
7	2
8	3
9	5
10	5

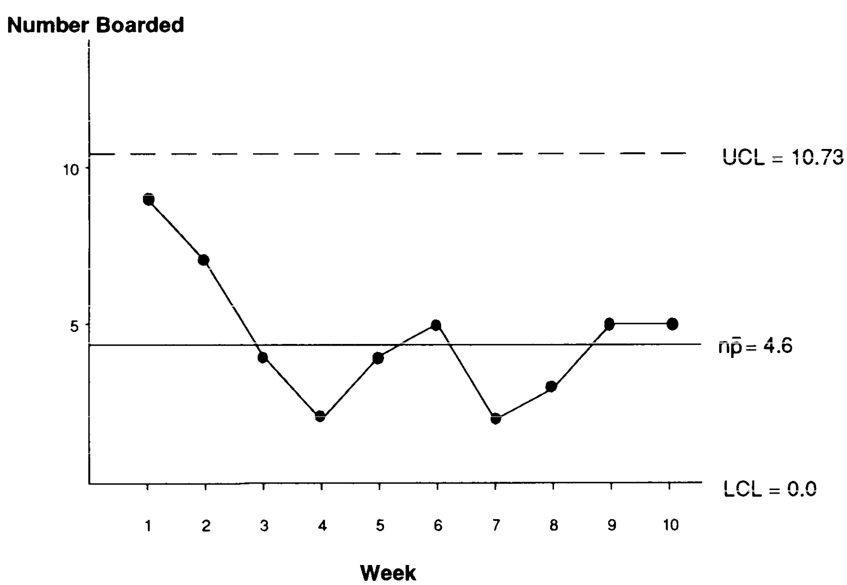


Figure A2-5. ECPs Boarded Per Week ($n\bar{p}$-Chart).

Control Chart Example 3:

System of Charts

The following is an example from SSD which used several types of control charts to analyze a Service Report process.

TABLE A2-7.
SERVICE REPORTS CONTROL DATA.

	Control Charts		
Sample Month	$\bar{X}$	R	p
1	143	244	0.71
2	139	348	0.71
3	116	337	0.54
4	84	9	0.54
5	88	155	0.52
6	60	133	0.54
7	90	154	0.6
8	210	294	0.51
9	125	241	0.74
10	51	29	0.47
11	56	64	0.62
12	65	56	0.39
13	143	351	0.43
14	—	—	0.65
15	—	—	0.7
Central Line	105	186	0.58
UCL	212	393	0.76
LCL	0	0	0.40

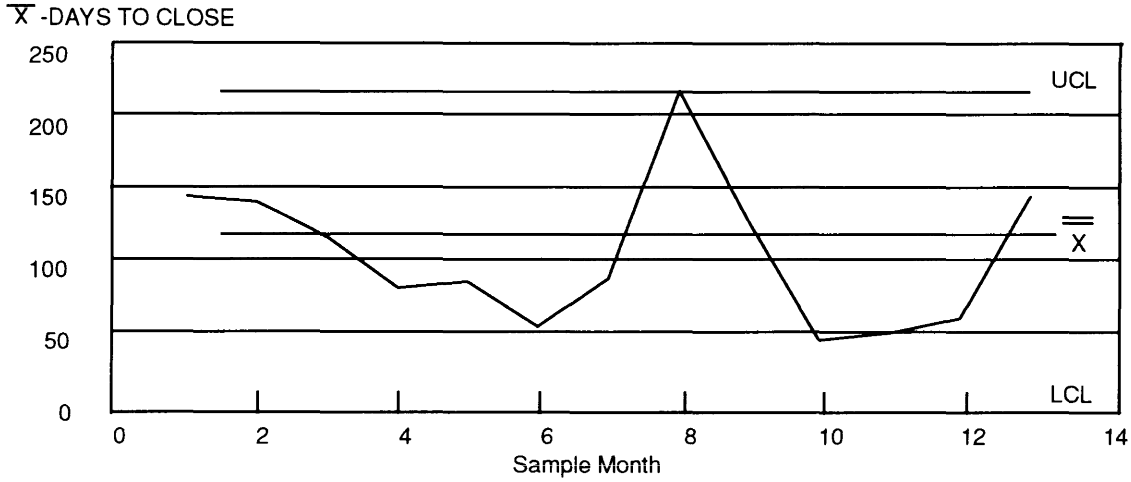


Figure A2-6. Service Reports Time To Close - Chart.

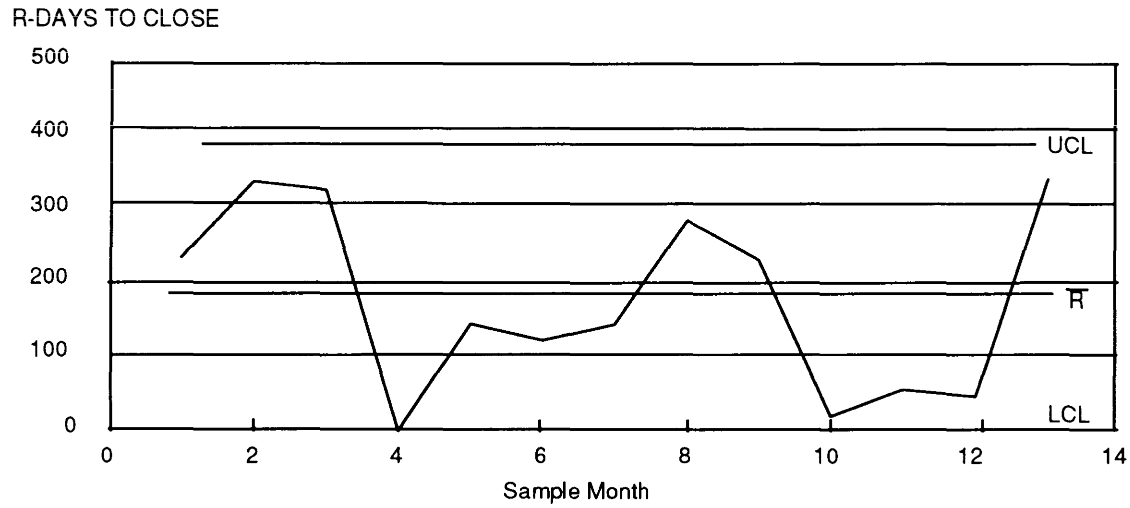


Figure A2-7. Time To Close p-Chart.

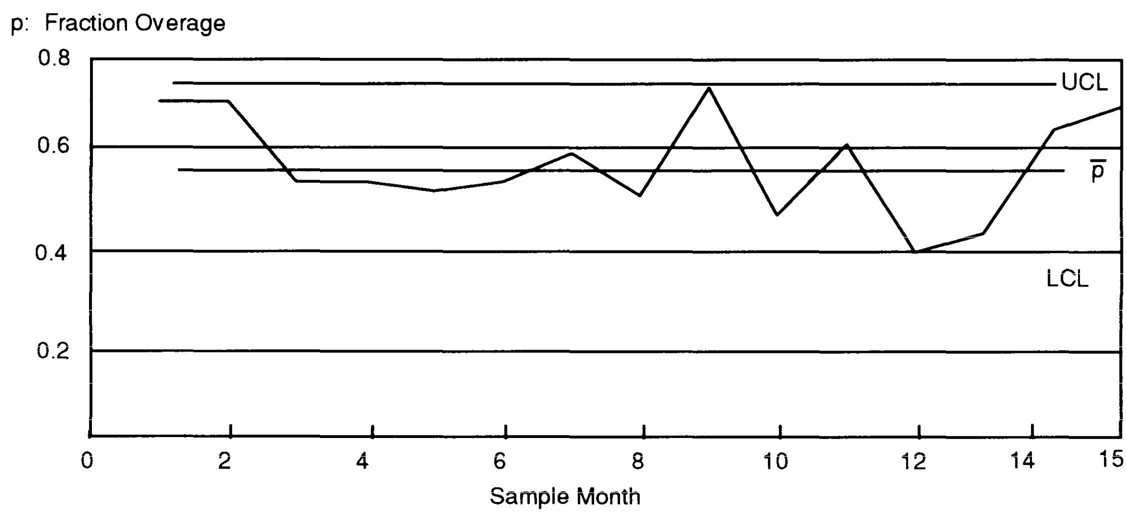


Figure A2-8. SR Fraction Of Open Reports Overage p-Chart.

Scatter Diagram

What It Is:

A scatter diagram is a graph used to reveal the possible relationship between two variables. It can help a group or individual:

- Identify possible causes of problems.
- Recognize the correlation between one important variable and another.

How To Use It:

- Collect the data in pairs. For each data point obtained for the first variable, a data point must be available for the second variable which represents the same time, location, or occasion. The larger the number of data points collected, the more reliable the conclusions drawn from the scatter diagram.
- Mark the horizontal axis with the name and units of measure of the variable suspected as being the causal or independent variable.
- Mark the vertical axis with the name and units of measure of the variable suspected as being the effect or dependent variable.
- Label the chart with descriptive titles and the appropriate timeframe. Divide and label both axes into increments which allow you to plot all data.
- Plot the data. As you plot each point, circle repeated points. Look for patterns in the data. Figure A2-9 will help you interpret patterns in the plot.

Points to Remember:

- This technique only shows that a relationship exists, not that one variable causes the other. In general, it is wise not to base conclusions about cause-and-effect relationships solely on the basis of a scatter diagram.
- As with all statistical tools, it is better to have more data than not enough. Scatter diagrams based on small sample sizes can be misleading.

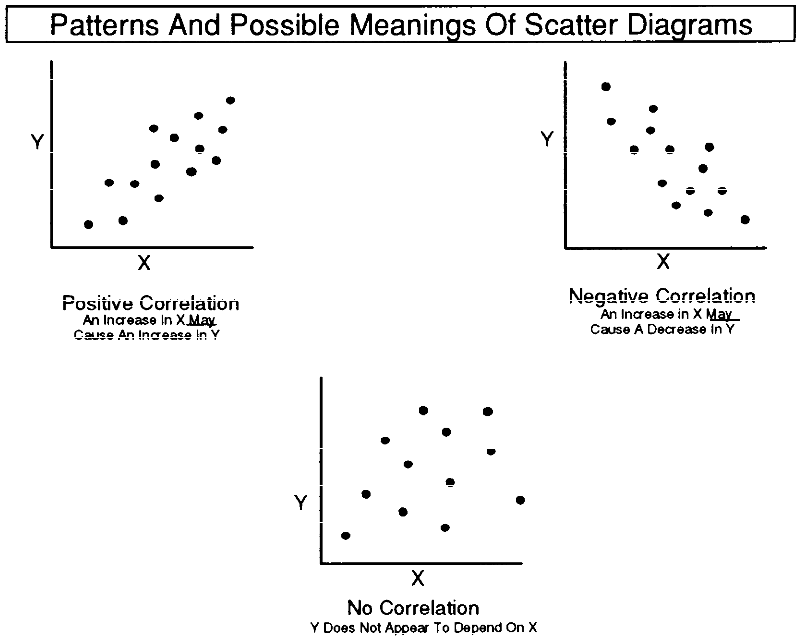


Figure A2-9. Scatter Diagrams.

Scatter Diagram Example:

This example shows actual data from a manpower study. The purpose of the measurement was to determine the possibility of a relationship for predicted workload.

TABLE A2-8.
WORKLOAD FACTOR STUDY DATA.

Work Center: Base Supply Funds Management
Workcenter Factor (WLF): An Item Record Loaded
WLF Definition: The average monthly number of Item records for base supply for which supply inventory section performs inventory.

Location	Manhours (Y)	Avg. Workload* (X)
Aviano	258.08	41.65
Bentwaters	323.81	65.64
Hahn	301.45	73.74
Lackland	279.56	16.86
Lowry	350.80	42.76
Williams	292.08	55.16
Little Rock	355.09	90.56
Hickam	265.24	72.50
Fairchild	405.44	72.43
Malmstrom	299.52	64.90
Pease	357.16	54.21
Whiteman	247.47	29.17
Edwards	438.11	101.75
Mt. Home	439.24	54.56
Myrtle Beach	340.76	40.23

* In Thousands

In plotting the measurement data in Table A2-8 on Figure A2-10, a strong positive correlation between manhours required and item records loaded became evident. This information was then regressed, and the results became the basis for manning levels at base supply shops.

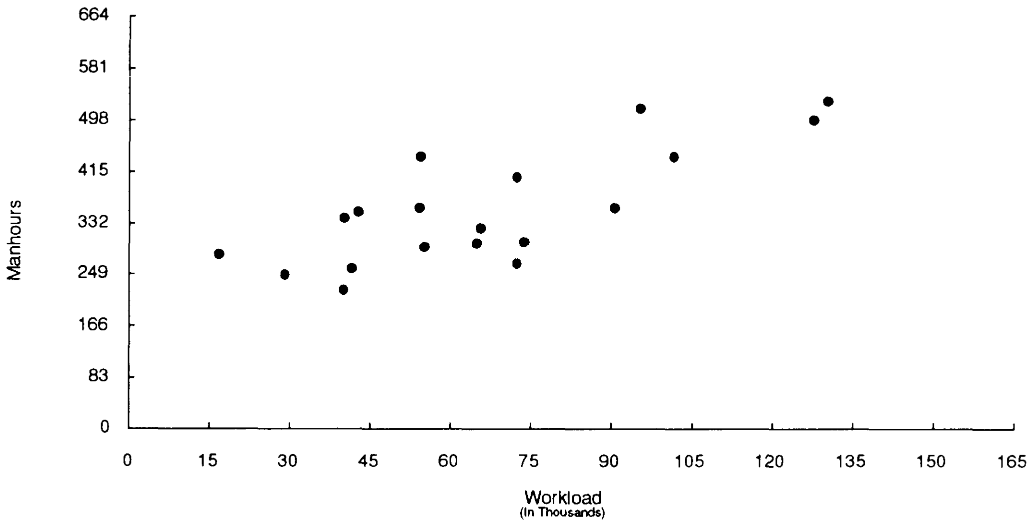


Figure A2-10. Workload Factor Study Scatter Diagram.

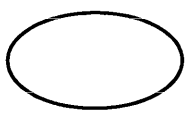
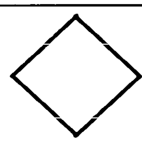
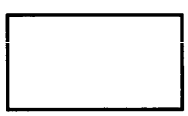
Flowchart

What It Is:

A flowchart is a graphic representation of all the major steps of a process. It can help:

- Understand a complete process.
- Compare actual to ideal process.
- Identify the critical stages of a process.
- Locate problem areas.
- Show relationships between different steps in a process.

**TABLE A2-9.
FLOWCHART SYMBOLS.**

This Symbol...	Represents...	Some Examples Are...
	Start/Stop	Receive Direction From Boss Submit Final Report Wake Up Go To Sleep
	Decision Point	Approve/Disapprove Accept/Reject Yes/No Pass/Fail
	Activity	Fill out Travel Voucher Walk Down To CBPO Brush Teeth Get Dressed

How To Use It:

- Define the start point and finish point for the process.
- Describe the current process, charting the process from beginning to end. Keep a macro-perspective, only into greater detail as you isolate problems or improvement opportunities. As a general rule of thumb, try to limit your macro flowchart to ten blocks. You can use the symbols shown in the figure to improve the clarity of your flowchart, but don't get hung up on symbols--the key value is in the sytematic thinking about and understanding of the process, not in the precision of drawing the flowchart.

- Consider the easiest and most efficient way to go from the "start block" to the "finish block." While this step isn't absolutely necessary, it does make it easier to do the next step.
- Search for improvement opportunities. Identify all the areas that hinder your process or add little or no value. Add detail to your macro flowchart to gain better understanding in those areas with the highest improvement and payback potential. A technique for constraint isolation is shown in Figure 6-3 is a very useful tool here.
- Build a new flowchart that corrects the problems you identified in the previous step. At this point you should be considering reengineering if the actual and improved processes are significantly different.

Helpful Hint:

Consider putting the steps of your process on index cards or sticky-back note paper. This lets you rearrange the diagram without erasing and redrawing. Making it easy to reconfigure the diagram encourages contributions.

Flowchart Example:

The following flow chart shows the administrative process for an Air Force Form 9.

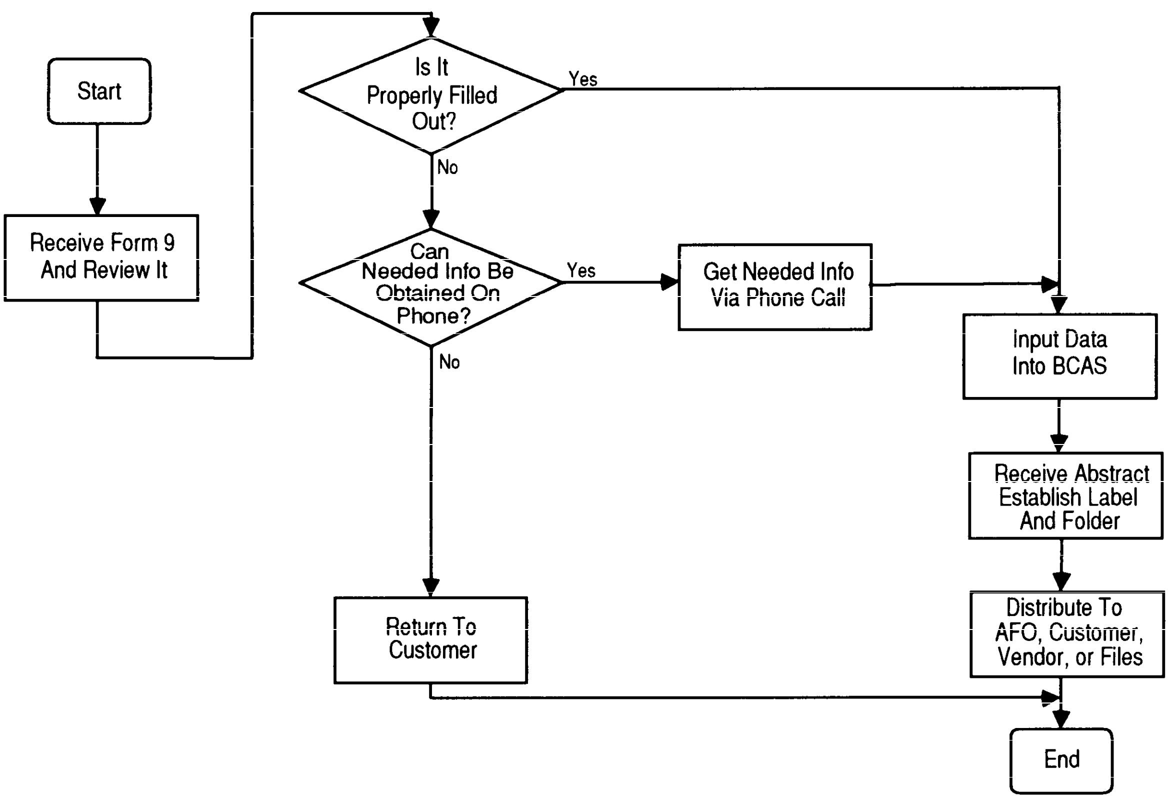


Figure A2-11. Flowchart For AF Form 9 Process.

Cause & Effect Diagram

What It Is:

A cause and effect diagram graphically illustrates the relationship between a given outcome and all the factors that influence this outcome. It is sometimes called an Ishikawa Diagram or a Fishbone Diagram. Cause and effect diagrams provide a structured approach to determining the root causes of a problem, an objective, or some other effect. They can be used to:

- Determine the factors that cause a positive or negative outcome or effect.
- Focus on a specific issue without resorting to complaints and irrelevant discussion.
- Identify areas where there is a lack of data.

How To Use It:

- Specify the effect you wish to analyze. Place it in a box on the right side of the diagram.
- List the major categories of the factors that influence the effects being studied. The "4 Ms" (methods, manpower, material, machinery) or the "4Ps" (policies, procedures, people, plant) are common starting points to help structure your thinking.
- Use an idea-generating technique to identify the factors and subfactors within each major category. An easy way to begin is to use the major categories as a catalyst. For example, brainstorm by asking questions such as these:

  How do our people influence . . .
  What regulations/policies affect . . .
  What procedures are causing . . .
  How does our equipment affect . . .

- Look for factors that appear repeatedly or are a root cause to the effect and list them.
- Prioritize your list of causes using a decision-making tool. Keep in mind that the location of a cause in your diagram is NOT an indicator of its importance. A subfactor may be the root cause to all of your problems.

Helpful Hint:

Consider using an objective instead of a problem as the effect to be discussed. A problem-oriented focus may produce "finger pointing," while focusing on desired outcomes fosters pride and ownership over productive areas. The resulting positive atmosphere will enhance the group's creativity.

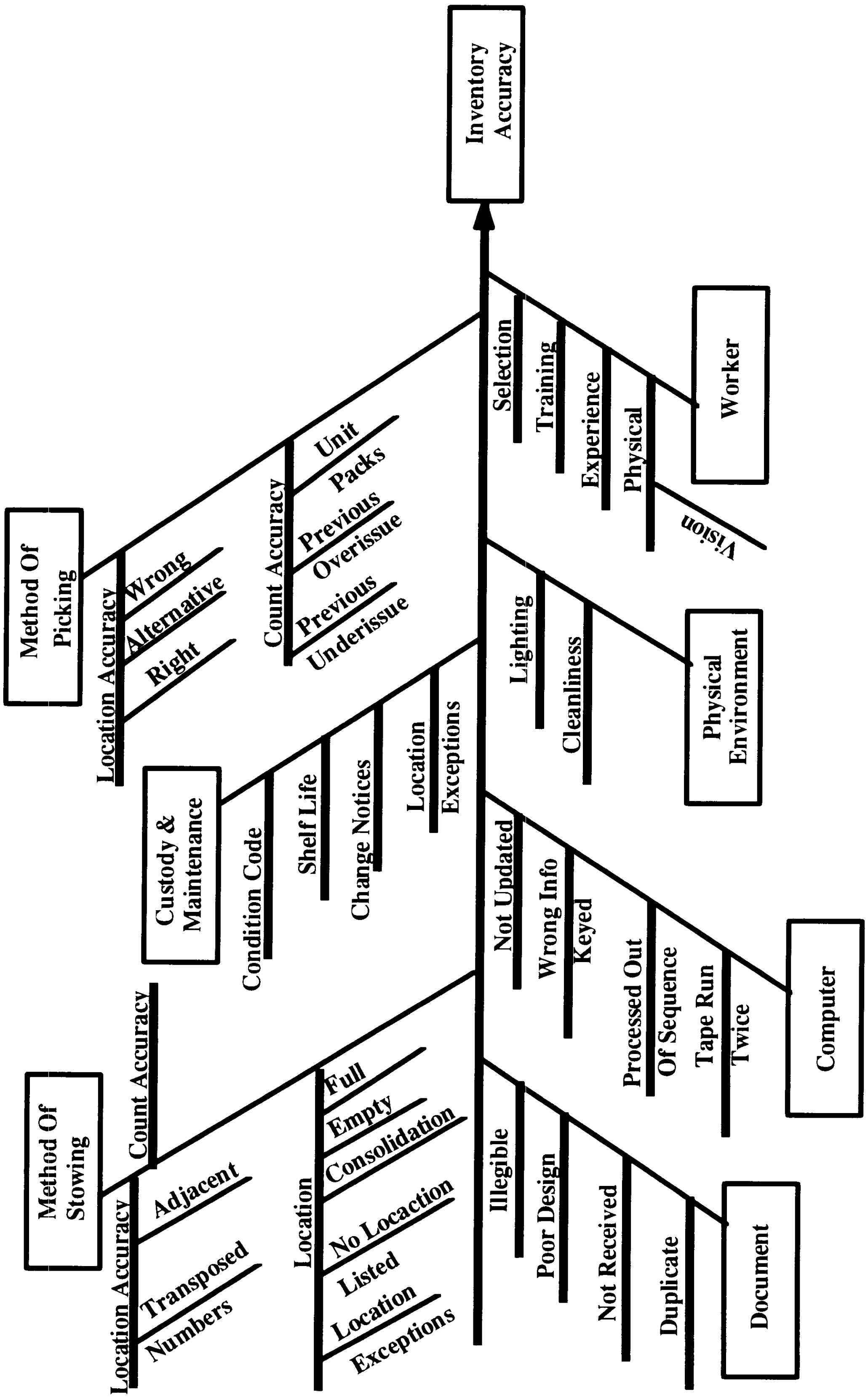


Figure A2-12. Error Free Documents Cause and Effect Diagram.

Checksheet

What It Is:

A checksheet is a simple form for collecting data in an organized manner and converting it into readily useful information. With a checksheet, you can:

- Collect data with minimal effort.
- Convert raw data into useful information.
- Translate opinions of what is happening into what is actually happening. In other words, "I think the problem is..." becomes "The data says the problem is...."

How To Use It:

- Clearly identify what is being observed. Clearly label the event you are observing. Everyone has to be looking for the same thing.
- Keep the data collection process as easy as possible. Collecting data should not become a job in and of itself. Simple check marks are easiest.
- Group the collected data in a way that makes the data valuable and reliable. Similar problems must be in similar groups.
- Try to create a format that will give you the most information with the least amount of effort.

Checksheet Example:

Table A2-10 presents data collected on Unfunded Requirement (UR) processing times in FY91. The checksheet shown in Table A2-11 gives a better understanding of this data.

TABLE A2-10.
UR PROCESSING TIME DATA.

Days To Process URs

OBS	Days	OBS	Days	OBS	Days
1	28	6	19	11	9
2	18	7	15	12	12
3	58	8	119	13	117
4	9	9	97	14	114
5	79	10	78	15	8

TABLE A2-11.
UR PROCESSING TIME CHECKSHEET.

Class (Days)	Observations	Total
0 - 9	III	3
10 - 19	IIII	4
20 - 29	I	1
30 - 39		0
40 - 49		0
50 - 59	I	1
60 - 69		0
70 - 79	II	2
80 - 89		0
90 - 99	I	1
100 - 109		0
110 - 119	III	3
Total		15

Pareto Chart

What It Is:

A Pareto chart is a bar chart used to separate the "vital few" from the "trivial many." These charts are based on the Pareto Principle identified by the Italian economist Vilfredo Pareto in the early 1900s when he observed that a relatively few people held the majority of the wealth. Later typified in a more generic form, the principle captures the idea that 20 percent of the problems are the "vital few" and the remaining 80 percent are the "trivial many." It applies to many situations; for example:

20% of the people do 80% of the work
20% of your customers give you 80% of your sales
In most charities 20% of the donors give 80% of the funds
You wear 20% of your wardrobe 80% of the time
You walk on 20% of your carpet 80% of the time

Pareto charts help groups and individuals:

- Separate the few major problems from the many possible problems so that improvement efforts can be properly focused.
- Categorize and prioritize problems and/or data.
- Determine which problems are most important using data--not intuition or perception.

How To Use It:

- Use idea-generation techniques to list all the possible problems in a particular process.
- Use existing reports or collect new data on the process. Be sure these units are consistent throughout your data.
- Label the units of measure on the left vertical axis and the categories of problems on the horizontal axis.
- Order the categories according to their frequency (how many) rather than their classification (what kind.) Use a descending order from left to right.
- Check that the labels are clear and identify the measurement units used.

Points to Remember:

- The measurement units used can significantly impact your Pareto chart. For example, 100 cosmetic-type defects may account for only a fraction of the total cost, while 2 material-type defects may account for a large percentage of the cost. You must determine if cost or number of defects is most important.
- It is essential to use the same units of measure, and clearly mark these units on the chart, ($,#,%,...).

Nested Pareto Charts:

Broad causes can be broken down into more specific areas to facilitate improvement efforts. These specific areas are "nested" within the broad causes, hence the term "Nested Pareto Charts." Figure A2-16 illustrates the concept of nested Pareto charts.

Stratification Analysis:

The same data can be plotted against different potential causes to determine the significant problem. This concept is very useful when your original Pareto chart doesn't clearly identify one or two significant problem areas. Use your imagination and be creative when you define your problem categories. Figures A2-14, and A2-15 show an example of stratification analysis. More information on stratification is found in a separate section under that heading.

Pareto Chart — Example 1:

An investigation of Laser Photography reliability was undertaken at AEDC because the existing 84 percent reliability did not meet customer requirements.

A sample of recent test shots showed 36 failures. These occurred in three categories: trigger failures, shot failures, and system failures. Of these 36 failures, 23 were trigger failures, 7 were shot failures, the remaining 6 were classified as system failures. In Figure A2-13, a simple Pareto Chart clarifies the area to investigate further. These failures were further investigated in Figures A2-14 and A2-15. These are examples of stratification.

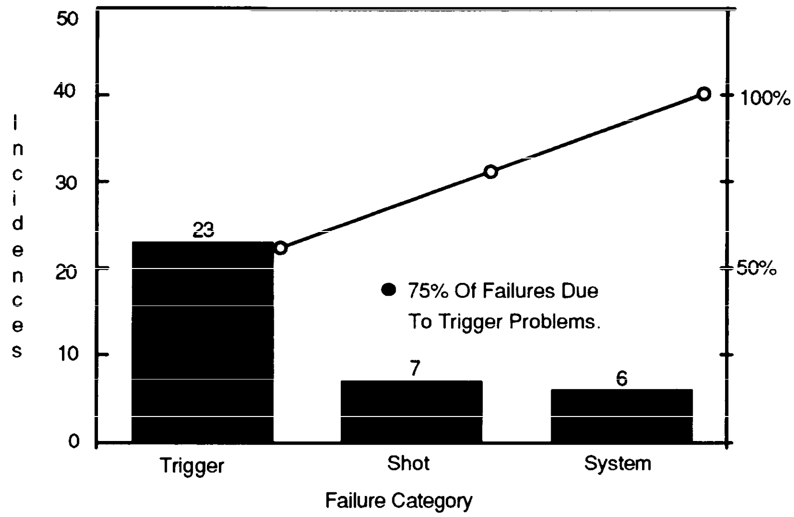


Figure A2-13. Laser Photography Failures.

This data identified trigger stations 24 and 8 as the main culprits of trigger failures. this led to a closer look at these stations. Marginal components at these stations were replaced and the trigger sensitivities were optimized. The data collection effort is continuing to determine if the problems located and addressed will result in improved performance.

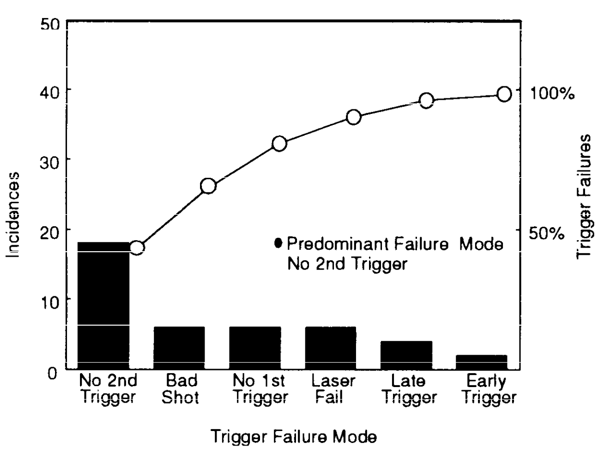


Figure A2-14. Trigger Failures.

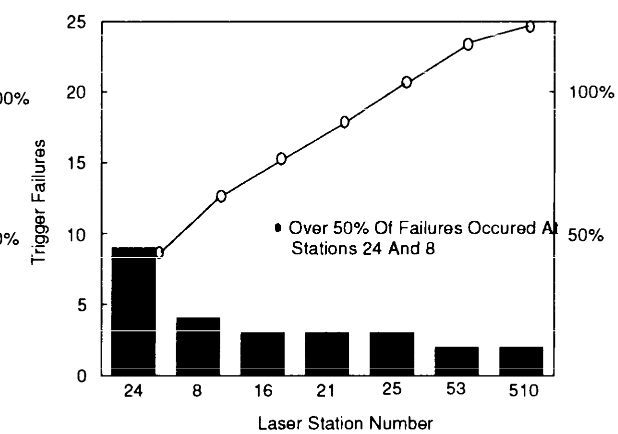
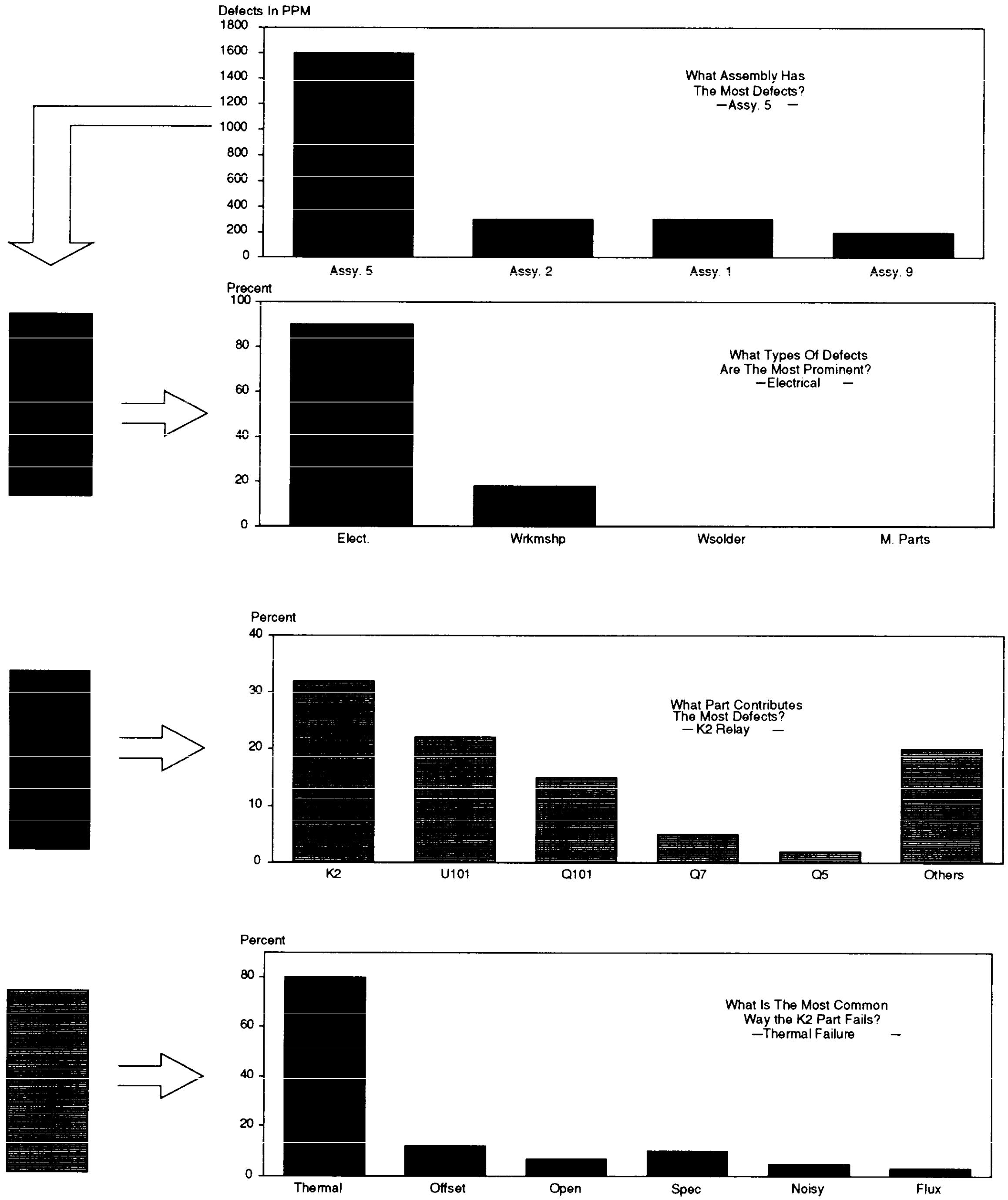


Figure A2-15. Laser Station Identification.

Pareto Chart Example 2:

Nested Pareto Charts



Used With Permission From Change Navigators, Inc.

Figure A2-16. Defect Analysis.

Histogram

What It Is:

A histogram is a bar graph used to depict the variability of a data set in the form of a frequency distribution. A histogram can help a group or individual:

- Display the variability in a data measurement.
- Quickly and easily assess the shape of the underlying distribution of a process.

How To Use It:

- Collect as many measurable data points, e.g., time, length, speed..., as possible.
- Count the total number of points you have collected.
- Subtract the smallest value in the dataset from the largest. This value is the range of your dataset.
- Divide the range into a certain number of intervals, or bars, on the graph. Use the following guidelines to determine the appropriate number of intervals to use.

Number of Data Points	Number of Intervals
Under 50	5-7
50-99	6-10
100-249	7-12
Over 249	10-20

- Divide the range by the number of intervals. Round your answers up to a convenient value. For example, if the range of the data is 17 and you have decided to use 9 intervals, then your interval width is 1.88. You can round this to 1.9 or 2.0. It is helpful to have intervals defined to one more decimal place than the data collected.
- Determine the starting point of each interval. Start with the smallest data point as the starting point of the first interval. Now add the interval width that you determined in the previous step. The sum is the starting point for the next interval. For example, if your smallest data point is 10, the next is 12 and so on. Label these intervals along the horizontal axis.
- Count the number of data points that fall within each interval and plot this frequency on the histogram. Keep in mind that each datapoint can appear in only one interval. For example, if your first interval begins with 10.0 and the second with 12.0, then count all data points that are equal to or greater than 10.0 and still less than 12.0 in the first interval.

Points to Remember:

- Each data point appears in one and only one interval.
- The number of intervals can influence the pattern your data will take.
- Don't expect the histogram to be a perfect picture; variations will occur. Ask yourself if the picture is reasonable and logically correct.

Histogram - Example:

Table A2-11 is a check sheet that originated from data collected on unfunded requirements HQ AFSC processed in FY 90. This check sheet was used to build Figure A2-17, a histogram that displayed the distribution of UR processing times.

TABLE A2-12.
UR PROCESSING TIME CHECKSHEET.

Processing Time(In Days)	Number Of Observations	Total	Range Mid-Point
0 - 19	~~IIII~~ ~~IIII~~ ~~IIII~~ ~~IIII~~ II	22	10
20 - 39	~~IIII~~ ~~IIII~~ ~~IIII~~ ~~IIII~~ ~~IIII~~	25	30
40 - 59	~~IIII~~ ~~IIII~~ ~~IIII~~ IIII	19	50
60 - 79	~~IIII~~ ~~IIII~~ II	12	70
89 - 99	~~IIII~~ IIII	9	90
100 - 119	III	4	110
120 - 139	III	3	130
140 - 159	III	3	150
160 - 179		0	170
180 - 199	IIII	4	190
200 - 360	~~IIII~~ II	7	240*

*Computed From Data Not Shown Here

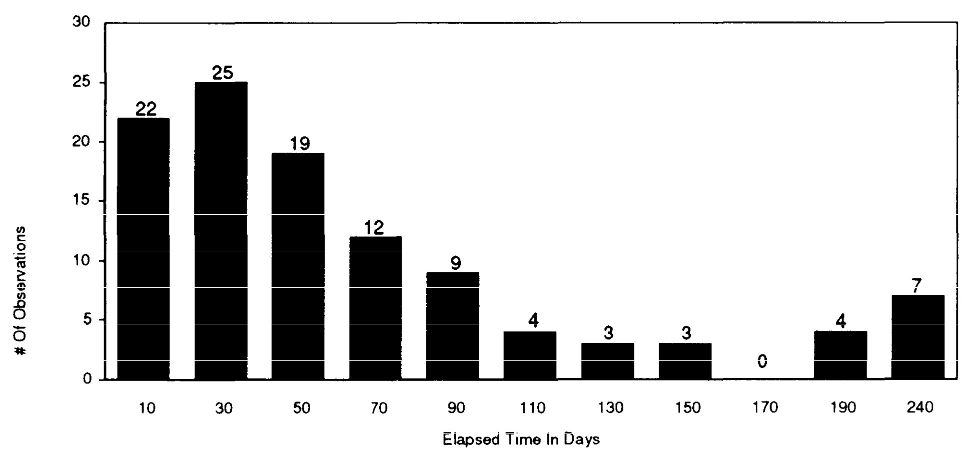


Figure A2-17. UR Processing Time Histogram.

Stratification

What It Is:

Stratification is helpful when your original Pareto chart does not clearly indicate one or two significant problem areas. Stratification is a fancy way of describing the "cutting" or "slicing" of data along different natural or logical lines, looking for underlying patterns. If patterns can be discovered, they help localize the problem or improvement opportunity and this is very valuable in zeroing in on root causes. The technique is similar to nested Pareto charts in the sense that you keep probing the data to obtain a clearer focus on potential problems or opportunities.

How To Use It:

Stratification is sorting data into groups or categories based on different factors. It is helpful to think about stratification before collecting data. In doing this, you want to focus on characteristics that might lead to biases in the data. These may not be causal factors, but potentially could lead to differences. Factors may include such things and dimensions as:

Type of job	Equipment
Day of the week	Team
Time	Product
Region	Season of the year

Other examples include the following:

-- Stratification of performance (efficiency) by functional area

-- Stratification of frequency of defects by functional area (process step)

-- Stratification of customer satisfaction by customer-type

-- Stratification of costs of defects by functional area (process step)

-- Stratification of costs of products by functional area (process step)

The Team Handbook (see Attachment 4) references an "Is/Is Not" matrix that might be helpful for sorting out knowledge and information for stratification.

An Example

Figure A2-18 shows some hypothetical data gathered by an acquisition organization. When the data were first charted by organization (product division), there appeared to be little difference. Sensing that there was still a potential "driver" or opportunity to improve, the analyst next stratified by contractor--again there was no significant difference. Finally, when data were examined by quarter, it was discovered that the 4th quarter was very different--this narrowed their focus to a particular area (time in this case) upon which to focus improvement efforts.

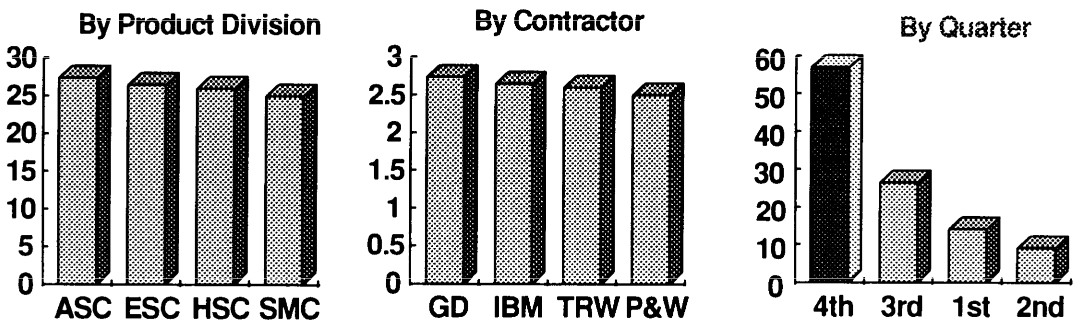


Figure A2-18. Three Different Stratifications.

Reengineering

What It Is:

Reengineering is the latest business revolution. According to Hammer and Champy, "America's business problem is that it is entering the 21st Century with companies designed during the 19th."[5] Reengineering involves abandoning the organizational and operational principles and procedures an organization is now using and creating entirely new ones. As depicted in Figure A2-19, reengineering means starting all over, starting from scratch!

How To Use It:

There is no prescribed formula for reengineering. Fundamentally one sets about reengineering by developing the *ideal* way a process (or processes comprising an organization) *should* work. This thinking should be completely unconstrained by current paradigms. Changes or "solutions" that have resulted from successful reengineering efforts have included these common characteristics:

-- Combining several jobs into one (integrating)
-- Compressing both vertically and horizontally
-- Empowering individual workers to a greater extent
-- Reducing checks and controls
-- Exploring customer/supplier partnerships
-- Designating a single point of contact for the customer
-- Performing process steps in a natural work order

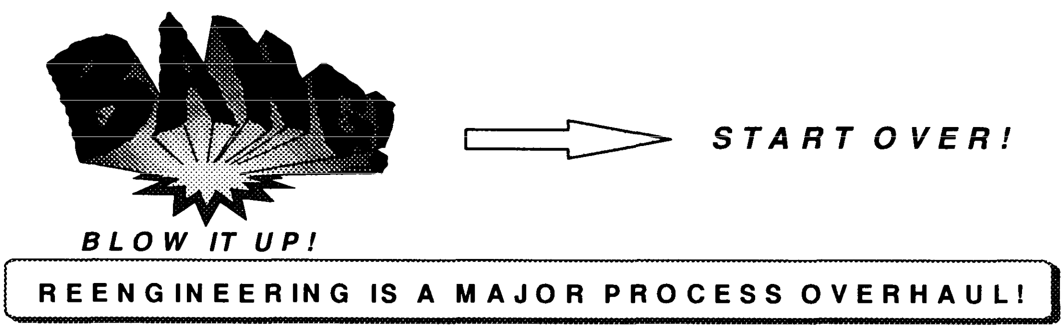


Figure A2-19. Reengineering Is Starting Over.

Points To Remember:

Although you may not be able to reengineer an organization in its entirety, you can apply the concepts at the process level. For example, the Integrated Weapon Systems Management (IWSM) concept with a "single-face to the customer" via System Program Directors reflects a fundamental reengineering of a management process. It required putting aside "the way we've always done it" to create a different approach.

---

[5] Hammer, Michael and James Champy. *Reengineering The Corporation: A Manifesto For Business Revolution.* New York, NY: HarperBusiness, 1993.

Theory of Constraints

What It Is:

The Theory of Constraints (TOC) utilizes two approaches to find root cause(s) or key points which determine the performance of a system. One is termed Throughput Analysis--it exposes the system's constraint where you should be concentrating your improvement efforts. The second approach is termed the Thinking Processes--these link together effects and their cause(s) to focus your attention on the primary underlying driver(s) of undesirable effects. Inherent in TOC philosophies is a system-wide perspective which examines local actions as they relate to the global organization. Below are some basic ideas to introduce you to some of the concepts of the Theory of Constraints. Further information can be gleaned from several books by Goldratt (see references section).

How To Use It:

Approach # 1: Throughput Analysis

First take a *system-wide* look to determine what's constraining the system as a whole. Every system has a weakest link (just as in the chain analogy). The weak link (constraint or bottleneck) literally defines the total system output/time (i.e., you can produce no more than your weakest link is capable of). Then focus your process improvement efforts at the constraint--improving the output of other "links" or activities will not improve the overall output of the system. Figure A2-20 illustrates the concept.

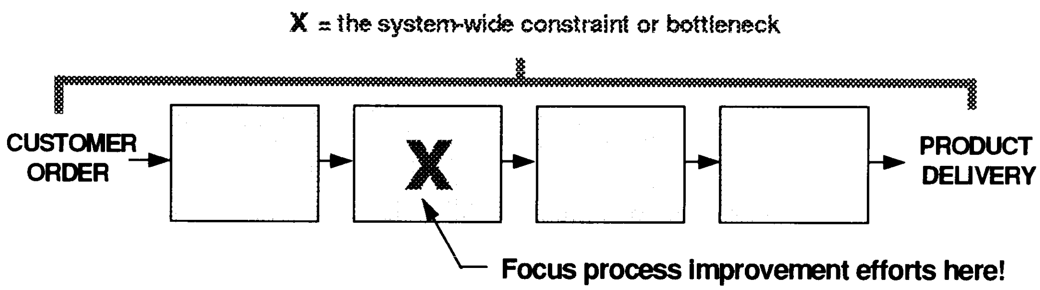


Figure A2-20. Throughput Analysis.

When a specific constraint has been alleviated, take another system-wide look and find the "new" constraint. Constraints will shift as process improvement efforts are applied and other external factors are levied upon the system (changes in product lines, resource fluctuations, market conditions, etc.). Throughput Analysis is an on-going approach that should never end, like continuous improvement.

Remember that local efficiencies do not tell the whole story; it is very easy (and often tempting) to focus on part of the system at the expense of the total system. Sub-optimization occurs when improvements are made at non-constraint steps (processes, activities, tasks) rather than at the constraint. Keep a systems perspective and balance resources relative to the constraint (weak link)!

Approach # 2: The Thinking Processes

This approach assumes that a few underlying causes explain many effects. The premise is that in any organization there exist many symptoms (called Undesirable Effects or UDEs) but only a few root causes. The Thinking Processes are a set of tools that use linked if-then logic statements to create a system model based on a network of logical operators. Developing the linkage allows one to trace UDEs back to their Root Causes. This can be extremely powerful because it readily exposes underlying assumptions and silent paradigms resident in all organizational networks. The five thinking process techniques are summarized in Table A2-13. In many cases, a skilled modeler

TABLE A2-13.
THE THINKING PROCESSES.

TOOL / METHOD	PURPOSE
Current Reality Trees	Understand what is going on today
Evaporating Clouds	Uncover underlying assumptions
Future Reality Trees	Create a vision of tomorrow
Prerequisite Trees	Overcoming obstacles
Transition Trees	Implementing required changes

can create a macro-level Current Reality Tree in a relatively short period of time, especially when compared to other modeling methods which are often time consuming, costly and stifle creativity and innovation via rigorous modeling methodologies.

Another important perspective concerns intangible "reasons" for why the organization does business a certain way. Under the Thinking Processes, one presumes that if there was a straightforward answer to the organizations' problems, one would have been found already. This leads to the acceptance of the fact that the majority of constraints afflicting an organization are not physical in nature, but rather intangible (called RTMs for Rules, Training, Measures) and the Thinking Processes help managers understand and alleviate those "givens" that might not otherwise be addressed as sources of a problem.

The following example illustrates how established rules and procedures can blind us to opportunities. In this case, fixation on the way a business had always allocated overhead and fixed costs resulted in a lost opportunity to earn huge profits.

> Several years ago an American auto manufacturer (AAM) was approached by a Japanese auto manufacturer (JAM) to build brakes for them. The AAM was using cost allocation as the basis for distributing all their fixed overhead costs to each product. This resulted in a price of $8.89 (notional data) per unit when they evaluated the JAM's offer to build brakes.
>
> The JAM pointed out to the AAM that the brake factory was operating at 40% capacity and that the proposed increase would bring their workload up to less than 60% of capacity. One shift was currently working only 3 to 3.5 hours of an 8-hour shift to meet current demand. Further the JAM offer would require no additional overhead, lighting, management, etc.--the only additional cost would be in raw material which would be $2.40 (notional) per unit. The JAM asked the AAM to reevaluate their offered price to build the brakes.
>
> The AAM went back and reworked their numbers--and returned with a figure of $8.89! The JAM restated their perspective and offered to pay $5.20 (notional) per unit--giving the AAM a per unit profit of over %100. Again the AAM examined their numbers and said they could only do it for $8.89. The JAM took their business elsewhere and the AAM lost a huge opportunity--all because they were blinded by a rule (i.e., a cost allocation method) that represented "the way they had always done it."

The Thinking Process can help you discover those RTMs that may no longer be valid and challenge them.

Benchmarking

What It Is:

David T. Kearns, former CEO of Xerox, defined benchmarking as "the continuous process of measuring products, services, and practices against the toughest competitors or those companies recognized as industry leaders." Benchmarking is another tool to add to your continuous process improvement toolbox for the specific purpose of adapting innovative practices for improvement. Benchmarking has the following benefits: it is proactive, it identifies improvement ideas, it has the credibility that comes from outside the organization and counters the "not invented here" mentality. It increases awareness about your own processes and their capabilities, and it helps you avoid being arbitrary in measurement and goal-setting. As you follow the benchmarking process, it entails leadership commitment to goal-setting. For a description of AFMC's approach to benchmarking, refer to AFMC Policy Directive 90-3 and AFMC Instruction 90-301, Organizational Comparison and Benchmarking. The references section of this Handbook also provides recommended literature on industry benchmarking, including the writings of Balm, Camp, and Spendolini.

Measurement:

Continuous improvement requires data and knowledge to guide change. If you want to improve, you must know where you are (baselining) and where you could be (benchmarking). Baselining is an accurate assessment of your current process. First, identify and gain a thorough understanding of your process. Next, measure and document your current process performance to establish your baseline. Use the quality tools mentioned in Chapter 4 to analyze your data. This baseline allows a starting point for comparing your process to similar ones used by other organizations who are performing at a higher level.

How to Benchmark:

Begin with a commitment to develop and use benchmarking tools as an integral part of the management process. The success of its implementation depends on management's backing and your flexibility. Management will need to see this as a means or tool to achieve the long term goals of the organization. You must be willing to learn from others, recognizing your own accomplishments, yet believing that you don't have all the answers and there is always room for improvement.

AFMC recommends the Air Force benchmarking process which integrates the best aspects of several models used in industry The following paragraphs address each phase of the model depicted in Figure A2-21.

THE BENCHMARKING PROCESS

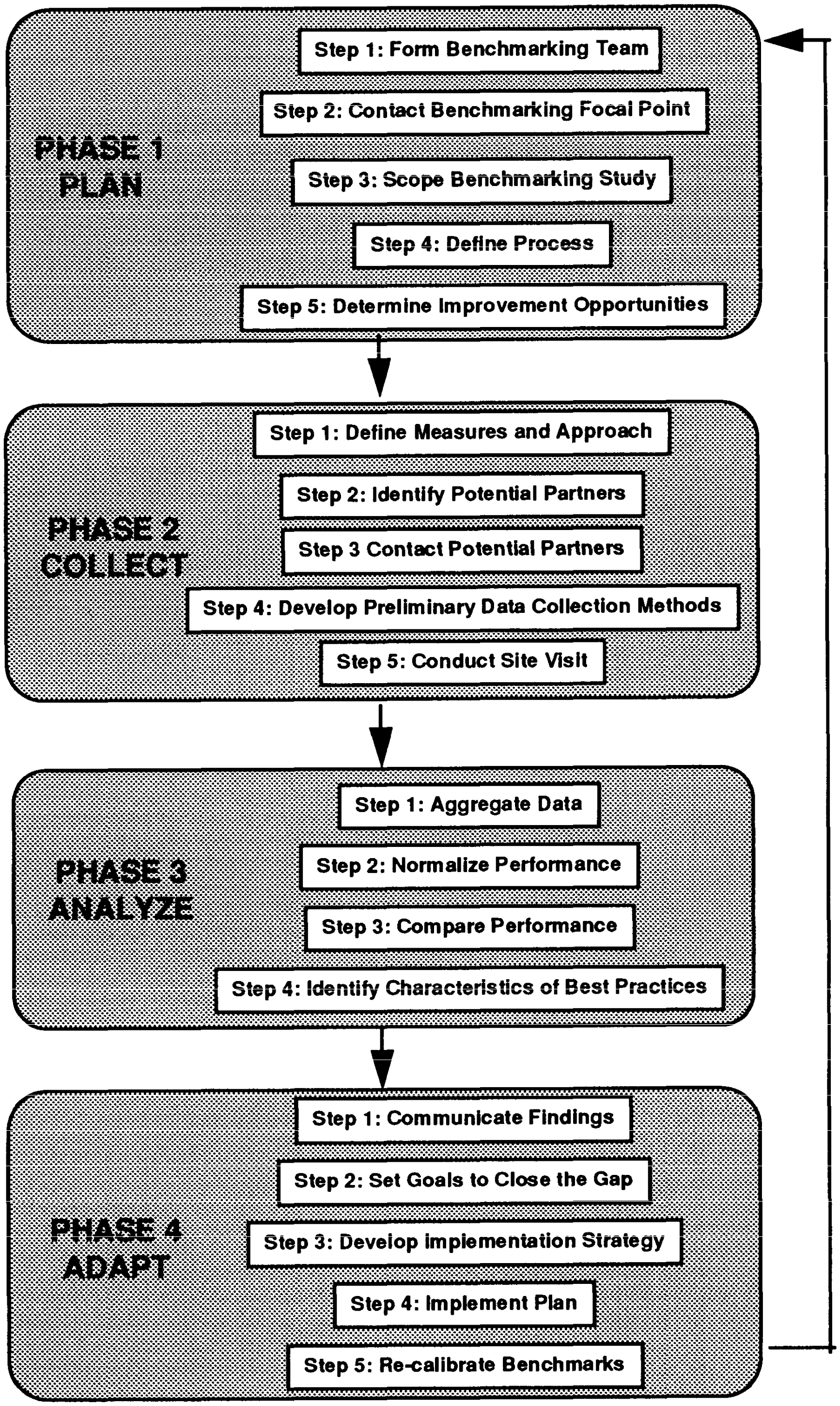


Figure A2-21. Benchmarking Process Steps[6]

[6] Air Force Quality Institute Benchmarking Course; AFMC Instruction 90-301.

Plan

During the planning phase of the study, the benchmarking team is formed, the scope of the study is determined, the specific process to be benchmarked is defined, the areas for improvement opportunity are selected, and topic areas for data collection are defined. AFMC has established benchmarking focal points within the headquarters directorates, mission elements, and each center who can provide assistance in initiating a benchmarking study. Team members should have experience working with the specific process being benchmarked and be knowledgeable of benchmarking techniques. Planning is typically the longest phase of the benchmarking process, taking up to 50% of the study time. The study must be scoped to ensure that the most critical sub-processes are included. The specific process to be benchmarked must be clearly defined: customers, inputs and outputs, process flows, activities, and measurements and metrics must be identified and clearly understood. Once the process is defined, it should be analyzed to determine constraining sub-processes--the areas that offer the greatest opportunity for improvement.

Collect

Data collection begins where planning ends: with the definition and approach for measuring the specific process, a clear statement of the process and process measures, the basis for comparison with others, and a method for analyzing results. Next, potential benchmarking partners are identified. These can be AFMC organizations or outside agencies and businesses that have similar processes, and are recognized leaders in their field. The third step is to develop preliminary data collection methods. Data collection should begin with internal analysis of the process, including understanding historical trends, cause and effects of past changes to the process, and cultural impacts on the process. The next step in data collection is external research, which involves studying existing data on potential benchmarking partners and their processes. This step should include collection and analysis of background information, measurement data, and screening and sorting data to ensure it is applicable to the study. External research can be conducted at libraries or clearinghouses. AFMC benchmarking focal points can provide assistance and procedures for interfacing with other AFMC focal points and clearinghouses external to the command. The final step in the data collection phase of the study is the primary investigation. During this step, the benchmarking team collects data directly from the benchmarking partner, through mailed questionnaires, telephone surveys, or interviews/site visits. This step enables the benchmarking team to investigate the specific practices and enablers that lead to superior performance. The key to a successful primary investigation is preparation--it is critical to the study that the benchmarking team understands what areas to focus on during interviews and site visits.

Analyze

During the analysis phase, you compare your process performance with the benchmark to find the gaps and determine what magnitude of improvement can be achieved. Data must be broken out by performance data and process information. Performance data reveals the gap between you and the benchmark, process information reveals how to close the gap. To be meaningful, data must be normalized between your organization and the benchmark, typically by setting ratios to make meaningful comparisons, such as cost per unit output, or revenue per employee. Once the data is normalized, it is easy to compare your current performance to the benchmark's performance, and define the gaps between the two. When the gaps are defined, cause and effect diagrams and root cause analysis can be employed to determine why the gaps exist, and how best to close them.

Adapt

The last phase of the benchmarking effort is adapting the improvements learned during the study. This phase involves assessing the adaptability of the enablers to your particular organization. Next, the benchmarking team must communicate its findings to the stakeholders. The third step is to set goals for closing the performance gaps, and develop an implementation strategy or action plan for achieving these goals. Action plans must define the specific actions required to change the current process to the new benchmark level of performance. Communication must continue throughout the changing of the process. Everyone involved must understand what changes are taking place and why. Communication should also address changes impacting customer satisfaction. Finally, recalibrate the benchmark and identify new benchmarking opportunities.

Levels of Benchmarking:

Benchmarking is an excellent approach to ascertain a company's relative strengths. By pitting your processes against others', much can be learned without reinventing the wheel. There are different levels of benchmarking including:

Level #1: Your [organization, process, task, activity] versus [.] "b"
Level #2: Your [.] versus the best in another AF MAJCOM
Level #3: Your [.] versus "Best in DoD"
Level #4: Your [.] versus "Best in this class" -- outside the gate
Level #5: Your [.] versus the Best in the World -- process vs. process
(not necessarily producing the same end-product)

One of the first places you should look for benchmarking comparisons is internal to your own organization. Who is doing something similar, perhaps in a different department or location? In AFMC, we have many "internal" opportunities. Competitive benchmarking is another excellent source. Here the products and services are similar, yet competitors' approaches may be different and provide improvement insights. Customers can provide valuable awareness of why they prefer certain product attributes of your competitors. Instead of focusing directly on the product or service, functional (e.g., warehouse operations, order processing, package handling, etc.) comparisons can also support benchmarking studies--even if the end products and services are very different. For example, an aerospace company might benefit by benchmarking against L.L. Bean's (a mail-order outdoor clothing distributor) warehousing process. Perhaps the most overlooked sources are generic comparisons--those functions or activities that are the same regardless of how dissimilar the organizations (e.g., billing, payroll, document processing, etc.).[7]

Points to Remember:

Your benchmarking comparisons involve the entire organization, a process, task, activity, "sub-process", or step that has the highest opportunity for improvement. You should look at several leading organizations. Take the time to research who is considered to be the industrial leaders and their competitors for various activities. For us in AFMC, this includes talking to other centers to see what they do particularly well and their sources.

It is important to find out who does what particularly well so you can learn from them. Try not to merely copy what they do; rather it is more important to understand what they do, how they do it, and why. Then look for ways to tailor those ideas to your organization. If you are at a loss on how to modify or improve what they are doing, there is nothing wrong with going ahead and copying them.

Most likely no single organization will have the exact formula you can use--you will conceivably need to pull many pieces together from several organizations. For example, when the automotive industry was having difficulty figuring out how to rapidly deploy airbags, someone likened it to an explosion. This idea eventually led them to a grenade manufacturer, thus bringing two dissimilar organizations together to solve the development of airbags.

Benchmarking is an iterative process--you don't become the best overnight or by benchmarking one time for a single improvement. Therefore, it isn't realistic that you can instantaneously do exactly as the world's best does--you need to take one step at a time to get to their level. Although you want to focus on the best, resource realities could dictate that you benchmark those organizations that are somewhere in between you and the best--anyone who is ahead of you can potentially provide stepping stones to achieve the desired improvements. Becoming the best should be your goal! Remember many benefits can be gained by the general ideas and principles of benchmarking--even if you can't apply the theory and techniques exactly.

[7] Camp, Robert C. *Benchmarking--The Search for Industry Best Practices that Lead to Superior Performance.* ASQC Quality Press, 1989.

Glossary

Action Plan • See Improvement Strategy.

Activity • Segments of processes that, when coordinated, could add up to a particular process.

Benchmarking • A reference point established by the performance or success of the "leading" organization within an "Industry" that can be used as a comparison point for other organizations in the same "Industry." This becomes the level of performance others strive to attain.

Best Practices • Closely related to benchmarks, these are the state-of-the-art process execution practices.

Cause • A proven reason for the existence of a defect.

Cause and Effect Diagrams • A diagram that graphically illustrates the relationship between a given outcome and all the factors that influence this outcome. Also called Ishikawa or Fishbone Diagram.

Center Metrics • These metrics track progress toward specific local objectives. In addition, centers will have metrics which support mission element metrics and objectives via the strategic planning process. They are reviewed routinely as part of local decision-making and the strategic planning process; serve as a basis for local process improvement actions; and reflect center-level contributions to MEB(s) supporting objectives. Center metrics and their corresponding improvement strategies (action plans) must support the overall mission element and command objectives while avoiding sub-optimization.

Check Sheet • A simple form used to collect data in an organized manner.

Command Metric • Command metrics measure progress toward our command objectives and reflect our overall command health. Command metrics are reviewed on a regular basis by senior leadership, usually by the Command Board, at each HORIZONS conference. Command metrics provide a view of the overall command with a cross-mission element perspective so that senior leaders can guide the strategic direction of AFMC. Command metrics may be comprised of individual mission element metrics elevated for command review.

Command-Level Metrics • These are metrics developed at HQ AFMC, recurring data requests from HQ AFMC requiring data from the field, data/metrics used to measure the field's performance, and/or data/metrics briefed above HQ AFMC directorates and staff offices. Command-level metrics do not include internal HQ AFMC directorate/staff metrics provided they do not task or report on offices outside of that directorate.

Common Cause • A source of variation that is always present; part of the random variation inherent in the process itself.

Control Charts • A tool used to analyze process variability over time. They measure the process in a time dimension and show movement toward or away from an average. Control charts have statistically calculated upper and lower control limits. Tool is most appropriate where change is undesirable, e.g., in the mass production of uniform products.

Control Limits (Upper (UCL) & Lower (LCL)) • Mathematically derived limits that represent upper and lower "bounds" for processes. There are alternative methods to calculate these; typically they are +/- three standard deviations from the mean. Control limits are used to help differentiate between common and special causes. Do not confuse these with customer expectations or product specifications.

Customer • An organization's customer is the entity (individual or organization) that requires a product or service that can be provided by the organization. The customer can be internal or external to AFMC. Normally metrics will focus on the products and services provided to customers external to AFMC, but recognize that your customer may the next person in your own process, i.e., internal to AFMC.

Data Providers • These are the organizations tasked to collect and submit the data supporting a metric; usually they are located at the point of data origination or process activity.

Executive Information System (EIS) • Executive information for decision-making and quick status review. Menu-driven software displaying command-level metrics. The Metrics Registry is also accessed through the EIS.

Fishbone Diagram • See "Cause and Effect Diagram."

Flow Chart • A graphic, structured representation of the major steps in a process.

"4Ms" • Major categories often used to build a Cause and Effect Diagram: Methods, Manpower, Material, Machinery.

"4Ps" • Major categories often used to build a Cause and Effect Diagram: People, Procedures, Policies, Plant.

Goal • A statement describing a desired future condition or change.

Headquarter's Directorate Metrics • These metrics track progress toward specific local objectives. In addition, centers and headquarters directorates and staff offices will have metrics which support mission element metrics and objectives via the strategic planning process. They are reviewed routinely as part of local decision-making and the strategic planning process; serve as a basis for local process improvement actions; and reflect center-level contributions to MEB(s) supporting objectives. Both center and headquarters directorate metrics and their corresponding improvement strategies (action plans) must support the overall mission element and command objectives while avoiding sub-optimization.

Histogram • A bar chart used to depict the average and variability of a data set.

Improvement Strategy • Each metric should have an improvement strategy (like an action plan) that identifies a continuous improvement philosophy for that metric. This includes identifying what behavior is desired, what actions are being taken to achieve improvement, and evaluations of progress. Included as part of the metric's operational definition.

Ishikawa Diagram • See "Cause and Effect Diagram."

Metric • A measurement taken over time, that communicates vital information about a process or activity. A metric should drive appropriate action and must be linked to the strategic planning process. The foremost purpose of the metric is to impel continuous improvement.

Metric Package • Three elements that physically make up a metric: (1) An operational definition, (2) Measurement and data recording, and (3) Improvement Strategy.

Metrics Registry • A central repository of current and proposed HQ AFMC metrics and those field metrics that directly provide data to HQ AFMC in support of headquarters-level metrics. The registry is accessed through the Executive Information System (EIS).

Mission • The single overriding purpose of an organization. It should encompass all of an organization's significant activities.

Mission Element Metrics • Those metrics established by each AFMC Mission Element Board (MEB). These metrics support the command objectives and metrics by measuring progress toward each MEB's specific mission element supporting objectives. They serve as a basis for process improvement at the mission element level and as a source of data for action plans and issues that must be elevated for command level deliberation. Mission element metrics are reviewed at MEB meetings and at their respective annual HORIZONS. Mission element metrics provide a cross-functional (headquarters directorates and centers) perspective of the mission element's contribution to the command goals and objectives.

Mission Elements • General categories for responsibilities within the command. These categories are broadly related to command mission areas. There are presently five mission elements identified: Program Management (PM), Test and Evaluation (T&E), Science and Technology (S&T), Base Operating Support (BOS), and Support and Industrial Operations (S&IO).

Objective • A more specific statement supporting one or more goals. It describes the desired future condition or change in terms more specific to a particular area.

Operational Definition • A detailed, unambiguous definition that provides enough information to allow consistent, repeatable, and valid measurement. An important component is the Improvement Strategy. See Attachment 1 for details.

Outcome • Perspective of the result from the entire mission-customer-product-process relationship. Provides bigger picture than just "output." For example, in building an aircraft weapon system, an *output* perspective would typically focus on how many aircraft were produced. In contrast, an *outcome* perspective would encompass the total, resulting capability those aircraft have--not just the number of aircraft, but also spare parts, support equipment, technical orders, training of people, etc. and how they work together as a system to meet the customers' requirements/expectations.

Output • The product, material, service, or information provided to customers. Typically is limited to a count of activity focus, i.e., how many made, number served, etc. An output perspective is susceptible to sub-optimization because it often does not include the whole system. See Outcome.

Pareto Chart • A type of bar chart used to separate the "vital few" from the "trivial many." Based on the Pareto Principal which states that 20 percent of the problems have 80 percent of the impact.

Process • Any specific combination of resources such as machines, tools, methods, materials, suppliers, and people employed to attain specific characteristics in a product or service. The process is typically described in terms of dependent tasks or activities which occur in a particular sequence.

Process Owner • An individual who is directly accountable for providing a specific product/service to the customer(s). A process owner may support customers internal to AFMC; however, he/she must subjugate the process to the end item process owner who provides a product/service to external AFMC customers.

Product • Result of a process. This may be goods or services.

Quality • All features and characteristics of a product or service that bear on its ability to satisfy stated or implied customer needs.

Quality Air Force (QAF) • The Air Force approach to total quality management: a leadership commitment and operating style that inspires, trust, teamwork and continuous improvement everywhere in the Air Force. QAF employs a myriad of management concepts and techniques proven in both Air Force and private sector world class organizations. Air Force implements QAF using a customer driven, comprehensive management system approach as described by the QAF criteria.

Quality Air Force (QAF) Criteria • Based upon the Malcolm Baldrige National Quality Award criteria, these provide a framework for evaluating and improving our processes and management systems for improved customer and mission support. The criteria address all elements of a management system including leadership, information and analysis, strategic planning, human resource development and management, process management, results trend data, and customer relationship management.

Range • The difference between the smallest value and the largest value in a data set.

Run Charts • A graph of process performance measures over time.

Service • Work performed for someone else.

Scatter Diagram • A type of graph used to reveal the possible relationship between variables.

Special Cause • A source of variation that is not always part of the process, but arises because of unusual, specific circumstances.

Stable Process • A process in statistical control; term is used with reference to the control chart technique.

Stakeholder • Stakeholders include any individual or organization that will have a significant impact or be significantly impacted by the metric. This includes the data providers. While frequent and clear communication with customers is essential, customers are not considered to be stakeholders for purposes of the metrics process. The stakeholders' primary responsibility is to work with the metric OPR to ensure that each metric is the right metric: beneficial to them, adds value, and drives the right behavior.

Statistical Control • The condition describing a process when the variation present in that process is consistently random and predictable over time. Term is used with reference to the control chart technique. Remember that statistical control in this sense only refers to observed behavior of the process and is not related to customer expectations, requirements, or specifications.

Statistical Process Control • The application of certain statistical techniques for measuring and analyzing the variation in processes. Tool is most appropriate where change is undesirable, e.g., in the mass production of uniform products.

Subgroup • One or more data points rationally grouped. Subgroups are used in control charts.

System • An interdependent group of items, people, resources, or processes with a common purpose. Typically associated with Input-Transformation-Output relationships. Definition of a particular system (i.e., where you draw the system boundaries) often depends on the problem at hand and/or the particular interests of an analyst or manager.

Task • Specific activity necessary in the function of a system or an organization.

TQ • Total Quality. A leadership philosophy, organizational structure, and working environment that fosters and nourishes a personal accountability and responsibility for quality and a quest for continuous improvement in products, services, and processes.

Trend • Measurements over time extending in a general direction.

User • An external organization or person who uses the final product or service.

Variation • Differences among individual outputs of the same process when the intent was to produce them with identical characteristics.

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